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# PERFORATING HEMORRHAGIC (CHOCOLATE) CYSTS OF THE OVARY

## THEIR IMPORTANCE AND ESPECIALLY THEIR RELATION TO PELVIC ADENOMAS OF ENDOMETRIAL TYPE ("ADENOMYOMA" OF THE UTERUS, RECTOVAGINAL SEPTUM, SIGMOID, ETC.)*

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The serious, though unusual, hemorrhage of ovarian origin into the peritoneal cavity simulating ruptured tubal pregnancy is well known to every abdominal surgeon, even though he may have encountered but few such instances in his own practice. The literature on this subject has been recently reviewed by Novak [1] and by Smith.[2] The larger ovarian cysts, also with hemorrhagic contents due to twisting of the pedicle of the cyst or from other conditions, are so obvious as to make it impossible to overlook them. Ovarian hematomas due to various causes have been reported by Savage,[3] Wolf,[4] Hedley,[5] Novak [6] and others.

There is, however, one type of hemorrhagic ovarian cyst or ovarian hematoma which should receive more careful attention; not only on account of its frequency but because of the nature of the adhesions resulting from the escape of its contents into the peritoneal cavity. These cysts are often bilateral and are usually small, from 2 to 4 cm. in diameter, though they are occasionally smaller than 2 cm.

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1. Novak, Emil: Abdominal Hemorrhage of Ovarian Origin, J. A. M. A. **68**:1160-1162 (April 21) 1917.

2. Smith, R. R.: Hemorrhages into the Pelvic Cavity Other than Those of Ectopic Pregnancy, Am. J. Obst. & Gynec. **1**:240-247 (Dec.) 1920.

3. Savage, S.: Hematoma of the Ovary and Its Pathological Connection with the Ripening and Retrogression of the Graafian Follicle, Brit. Gynaec. J. **21**:285-305, 1906.

4. Wolf, E. H.: Ueber Haematoma Ovarii, Arch. f. Gynäk. **84**:211-243, 1908.

5. Hedley, J. P.: Hematoma of the Ovary with Report of Eighteen Cases, J. Obst. & Gynec. Brit. Emp. **18**:293-311, 1910.

6. Novak, Emil: Hematomata of the Ovary Including Corpus Luteum Cysts, Bull. Johns Hopkins Hospital **28**:349-354 (Nov.) 1917.

and larger than 4 cm. They apparently develop in women during their menstrual life, especially from 30 years of age to the menopause. I believe that many of the cases described by Savage,[3] Wolf[4] and Hedley[5] belong to this group. A very good example of this type of cyst is described by Smith,[2] under the title of hematoma ovarii.

At operation the ovary containing such a cyst is found to be adherent because of a previous perforation and is ruptured in freeing it. The perforation had been sealed by whatever structure the cyst, at that site, had become adherent to, such as the posterior wall of the uterus, posterior layer of the broad ligament or peritoneum of the side of the pelvis.

During some period in the life of these cysts (or possibly many times), material escaped from them into the peritoneal cavity which was very "irritating" and gave rise to adhesions. These adhesions occur most often in the dependent part of the pelvis, namely the culdesac.

The contents which escape, in freeing the cyst at operation, look like chocolate syrup. The amount varies with the size of the cyst, the size of the opening and the consistency of the contents. Adhesions are encountered which vary in extent, density and location in different cases. They may be slight, as those resulting from a mild pelvic peritonitis of tubal origin, or extensive and dense causing the parts involved to become fused with one another and thus making their separation extremely difficult. The most extensive and densest adhesions are usually found in the culdesac uniting the supravaginal portion of the cervix and lower portion of the posterior wall of the uterus to the bottom of the culdesac and the anterior rectal wall. These adhesions vary in extent and degree in this situation and are sometimes so dense as to simulate malignancy. The operator deals with the individual case according to his best judgment at the time and usually considers the adhesions due to some previous pelvic inflammatory disease. For many years, this was my attitude toward this condition, and judging by the gynecologic textbooks which I have consulted (fifteen in number) all but two of the writers were either unaware of the adhesions resulting from the rupture of ovarian hematomas or did not consider them of sufficient importance to mention them. The two authors who do mention them refer briefly to adhesions resulting from the rupture of an ovarian hematoma or hemorrhagic cyst.

I believe that the whole subject is of great importance from an economic, clinical, pathologic and even physiologic point of view. These cysts are of frequent occurrence. I have had fourteen cases during the year, May 1, 1920, to May 1, 1921, in 178 abdominal operations for pelvic conditions in women between 30 and 50 years of age.

They affect women in a most valuable period of their lives, usually from 30 years of age to the menopause. The variation in size of the cysts, with the varying extent and denseness of the adhesions, leads to mistakes in diagnosis both before and during the operation. The smaller cysts with slight or moderate adhesions may be mistaken for pelvic inflammatory disease of tubal origin; the larger cysts with dense adhesions for malignant ovarian cysts and the dense adhesions in the culdesac for the implantation of cancer, or, when the rectal wall is extensively involved, for rectal cancer. Many kinds of operations have been performed to relieve the condition resulting from these cysts:

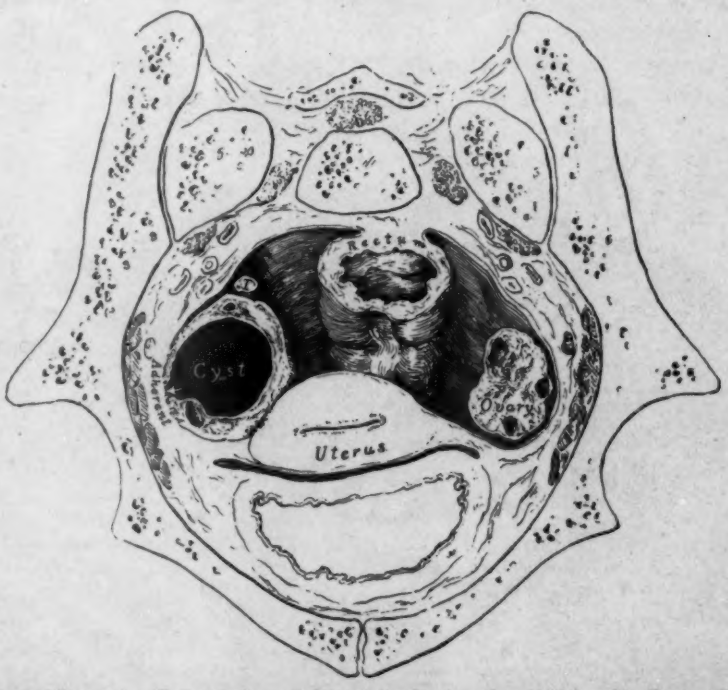


Fig. 1 (Case 11).—Cross section of the pelvis showing the condition found at operation; × ½. The ovarian cyst had ruptured and the perforation was sealed by the peritoneum of the side of the pelvis to which the ovary had become adherent. On freeing the ovary, its "chocolate" contents escaped. The histology of the ovary is shown in Figures 2, 3 and 4. Tissue was not removed from the side of the pelvis adherent to the ovary to determine whether or not adenoma of endometrial type was present.

conservative operations in which the adhesions have been severed, a portion of an ovary excised or one tube and ovary removed; radical operations, with the removal of the uterus, tubes and ovaries, and still more extensive operations in which a portion of the large intestine has been excised, with or without the removal of the uterus, tubes and ovaries.

Of histologic and pathologic interest is the finding in these ovaries of tissue of endometrial type lining the wall of the hematoma and also

often in pockets in the ovary especially about the site of perforation. This tissue may also often be found in the structures which are involved in the adhesions, as the organ or tissue to which the ovary or cyst is adherent at the site of perforation and in the folds formed by the tube and ovarian ligament, the tube and the round ligament, the vesico-uterine fold of peritoneum, about the uterosacral ligament, and bottom of the culdesac, namely, in places in which the hemorrhagic contents escaping from the rupture of the ovarian hematoma would be likely to settle. The most extensive development of this adenoma of endometrial type is usually found in the culdesac, sometimes as a localized thickening; other times as a diffuse growth involving the posterior surface of the supravaginal portion of the cervix, the posterior uterine wall, the bottom of the culdesac and the anterior wall of the rectum, all of which may be adherent to one another. The process

Fig. 2 (Case 11).—Enlargement (× 4) of a stained cross section of the ovary, cyst collapsed and empty. The cyst *c* is for the most part lined by low epithelium which lies directly on the ovarian tissue with ut any intervening stroma (Fig. 3). There are in the ovarian tissue about the perforation *p* depressions or small clefts *e* lined by columnar epithelium with gland formation and a stroma which is vascular and in places hemorrhagic. These areas strongly suggest misplaced uterine mucosa (Fig. 4). From a histologic study of this cyst one would hesitate to say that it is a hematoma of endometrial type. Nevertheless, hematomas may be found in "adenomyoma" of the uterus with a similar lining. The latter should be our standard of comparison in studying ovarian hematomas rather than the normal uterine mucosa (Fig. 6).

may even extend out between the layers of the broad ligament or between the rectum and vagina, the latter giving rise to "adenomyoma of the rectovaginal septum."

Of physiologic interest, it is to be noted that the adenoma of endometrial type developing in the ovary and arising in the portion of the pelvis as the result of the escape of the hemorrhagic contents of the ovary may be the seat of periodic hemorrhages, i. e., they may be "menstruating organs." Such hemorrhage or menstruation from the ovary would escape into the cavity of the cyst or into the peritoneal

cavity to be absorbed or to give rise to secondary foci of adenoma of endometrial type in various portions of the pelvic cavity. The secondary pelvic foci usually remain quiescent except for slight hemorrhages into the lumen of the glandlike spaces forming small "hematomas" (hemorrhagic cysts). Sometimes they are invasive, and when so are apt to invade the uterus, forming an "adenomyoma" or they may grow down between the rectum and the vagina, forming an "adenomyoma of the rectovaginal septum" and may penetrate the vagina and appear in the posterior vaginal vault. In other cases, they may extend through the wall of the rectum or sigmoid. The "menstrual" blood may escape into the vagina or the large intestine depending on which structure is penetrated by the growth.

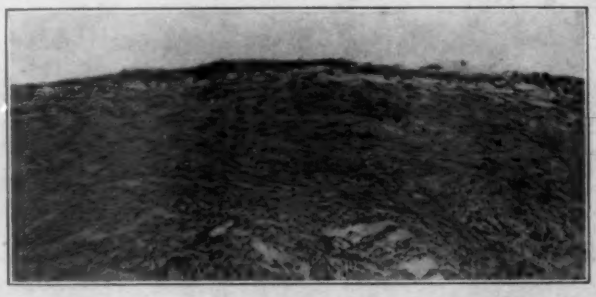

Fig. 3 (Case 11).—Photomicrograph of the wall of the cyst shown in Figure 2. The cyst is in places lined by a single layer of low to cuboidal epithelium resting directly on the ovarian tissue without any intervening vascular stroma. The condition is similar to that shown in Figure 6, a section of the wall of a hemorrhagic cyst due to the retention of "menstrual" blood in an "adenomyoma" of the uterus.

## THE INCIDENCE OF PERFORATING HEMORRHAGIC CYSTS OF THE OVARY

My attention was first directed to the dense peritoneal adhesions which may result from the escape of the contents of these cysts, in the year 1910 (Case 1). At the operation, March 8, of that year, a myomatous uterus with bilateral adherent, medium-sized ovarian cysts was found. When these cysts were freed, "chocolate" colored fluid escaped. The lower portion of the posterior uterine wall was firmly adherent to the rectum, and these structures were separated with great difficulty. The supravaginal portion of the cervix was so adherent to the rectum that a supravaginal hysterectomy was performed and the pelvis drained through the dilated cervical canal. The anterior rectal wall felt so indurated after the removal of the uterus that I thought the patient might have a malignant growth of the rectum. I made a digital rectal examination before the patient left the operating room.

While the induration in the anterior rectal wall could be distinctly detected, the rectal mucosa over it felt normal. The patient developed a postoperative ileus which was relieved by an enterostomy. She eventually recovered and has never had any trouble from the rectal condition. At the time I thought that the condition might be syphilitic and advised her family physician accordingly. In view of my present knowledge of these conditions, I believe that the adhesions probably arose from the cyst contents and that there was present an "adenomyoma of the rectovaginal septum." It was only after I had removed other similar cysts that I began to recognize that the adhesions accompanying these cysts arose from the escape of their hemorrhagic contents into the peritoneal cavity. I have since been impressed with the fact that the diagnosis of such a definite clinical and pathologic entity should be made before the operation.

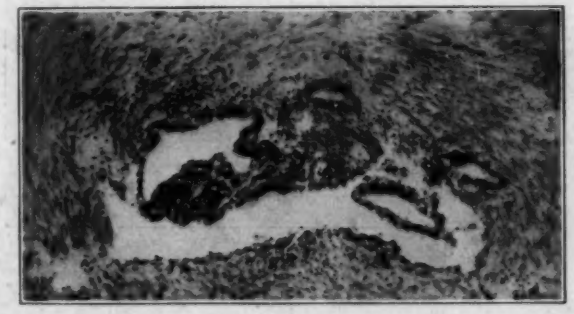

Fig. 4 (Case 11).—Photomicrograph of a small pocket (*e*) in the periphery of the ovary near the perforation of the cyst shown in Figure 2. Histologically, it closely resembles endometrial tissue, the epithelium, stroma and gland formation are the same. This tissue did not resemble the depressions lined by the typical surface epithelium of the ovary which were present in the same section.

The association between these cysts and "adenomyomas" of the posterior uterine wall with adhesions between it and the rectum was first observed by me, in 1912. March 27 of that year, I removed an "adenomyomatous" uterus in which the "adenomyoma" had apparently extended through the posterior uterine wall and had invaded the anterior wall of the rectum (Fig. 64, Case 2). On section, the "adenomyoma" was apparently not connected with the uterine mucosa. Bilateral perforating hemorrhagic cysts of the ovary were present. Just a month later I encountered a similar condition which would have been overlooked had it not been for the first, as the "adenomyoma" was much less extensive (Case 3 and Fig. 63). I did not observe another similar condition until June 13, 1918 (Case 6), but I undoubtedly had overlooked many. During the years 1918 and 1919, I observed

these cysts many times and studied them more from the standpoint of gross pathology, basing the microscopic studies solely on the routine examination of the material in the pathologic laboratory. I found that this was inadequate, and, therefore, I am reporting only a few of the cases observed by me during that period. Until a year ago, I believed that the adhesions arose solely because the contents were exceedingly irritating; that they contained a digestive ferment (menstrual) or were infected by some bacteria. Cultures were made and proved sterile, and some experimental work on animals was done which will be considered later.

It was only this last year that I fully realized the true relation between these cysts and pelvic adenoma of the endometrial type and

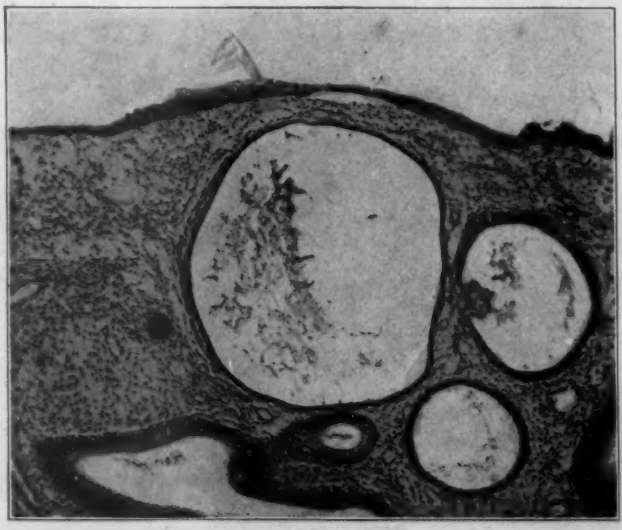

Fig. 5.—Photomicrograph of a portion of uterine mucosa showing glandular dilatation. The epithelium lining these glands is columnar, cuboidal or low varying with the dilatation of the glands. The greater the dilatation (distention), the lower is the epithelium lining the gland. The same holds true for hematomas of endometrial type whether of the ovary or the uterus. (Compare with Figure 3 and also Figure 6.)

that the pelvic adhesions were often associated with or were in large part due to this adenomatous growth.

From May 1, 1920, until May 1, 1921, I have operated on fourteen patients with these cysts, and in ten, an adenoma of the endometrial type was found in the organs or tissues which were adherent. In the four in which it was not found, the adhesions were slight, conservative surgery was performed and tissue was not removed from the adherent structures for microscopic examination.

## PATHOLOGIC ANATOMY

*A. Pathologic Changes in the Ovary.*—As previously stated, these hemorrhagic cysts are found at operation to be adherent, and in freeing

them, the cyst is ruptured and some, or all, of its contents escapes. This rupture arises from reopening a previous perforation which has been sealed by the organ or structure to which the cyst has become adherent at the site of the perforation, or the cyst is torn in freeing it. Adhesions are also found in other portions of the pelvis and especially in the culdesac, and these adhesions are apparently the result of the escape of the contents of the cyst. The cyst with the evidence of a previous perforation is often the only apparent cause for the adhesions which occur in situations where fluid or contents from a ruptured cyst would tend to fall or accumulate. I have found at operation, in four instances, evidence of recent "hemorrhage" into the pelvis from this source. The situation and extent of these adhesions vary greatly in different cases. The pathologic conditions found at operation also vary and depend on many factors, such as the size of the cyst, its situation in the pelvis, whether unilateral or bilateral, the situation and extent of the adhesions

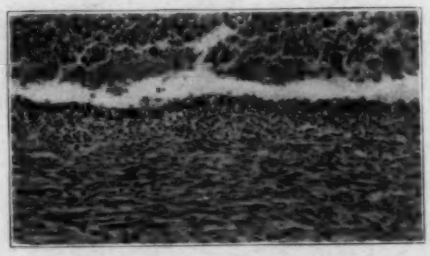

Fig. 6.—Photomicrograph of the wall of a hemorrhagic cyst (hematoma) present in an "adenomyoma" of the uterus. This hemorrhagic cyst is due to the retention of "menstrual" blood. It is lined by a single layer of epithelium, cuboidal on the left and low on the right. The epithelium rests on the uterine tissue with little or no evidence of an intervening "endometrial" stroma. The hemorrhagic contents of the cyst are shown retracted above the epithelial lining. Histologically, the lining of this hematoma (uterine) and the one shown in Figure 3 (ovarian) are similar.

and secondary changes associated with, or arising from, these, and finally other pathologic conditions in the pelvis which may occur in women of the same age incidence.

The size of the cysts has already been discussed. It is usually between 2 and 4 cm., occasionally larger; the largest one in this series was approximately 9 cm. in diameter. They are often bilateral, eight out of the twenty-three cases in this series; when unilateral, the right ovary was involved in nine, and the left, in six instances.

The structure or organ to which the cyst is adherent at the site of perforation varies. In this series of cases the posterior surface of the uterus was most frequently involved (Fig. 38); then the posterior surface of the broad ligament (Fig. 27); the peritoneum lining the side of the pelvis (Fig. 1), and in one instance the anterior surface of the broad ligament and the round ligament (Fig. 47), that is, any

organ or structure which may be in contact with the ovary or cyst at the site of perforation. There are two rather characteristic features about the gross appearance of these cysts after their removal. One is the perforation with a raw area of ovarian tissue about it, where it was adherent (Figs. 16 and 37), and the other is that these cysts usually differ from the ordinary retention cysts of the same size in that the walls are thicker, and after the contents have escaped, they stand apart and do not collapse to the same degree as do the others (Figs. 2, 17 and 28). The size of the perforation varies with the amount of trauma done at the time of operation in freeing the ovary. The situation of the perforation is of interest. I have always found it either on the lateral

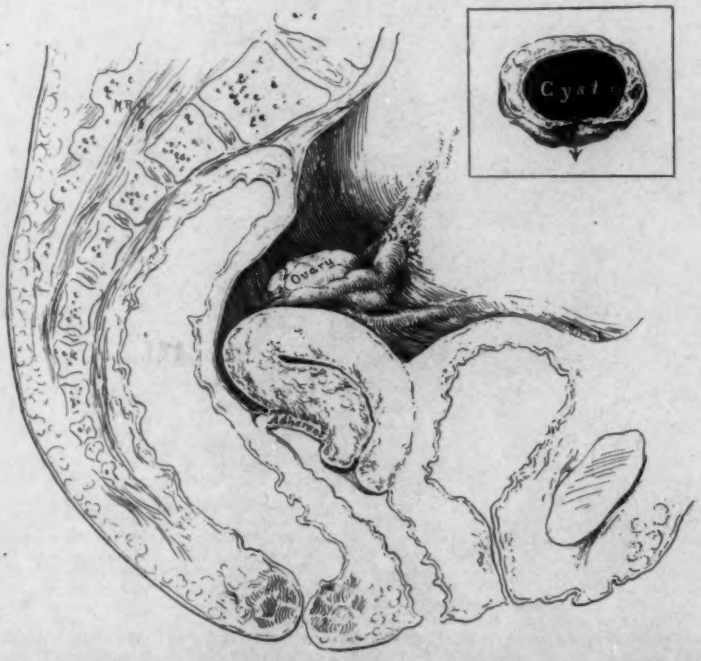


Fig. 7 (Case 10).—Perforating hemorrhagic cyst of the left ovary with adherent retroflexed uterus. Sagittal section of the pelvis; × ½. The cyst of the left ovary had ruptured, causing adhesions between it and the posterior layer of the left broad ligament and also between the posterior wall of the uterus and the anterior wall of the rectum. The histologic structure of the hemorrhagic cyst is shown in Figures 8, 9 and 10. Sections were not made of the adherent pelvic structures. Therefore, it was not determined whether or not adenoma of the endometrial type was present in these tissues.

surface of the ovary (Figs. 16 and 37) or on its free border (Fig. 28), and have never found it on the mesial surface. Even when adherent to the posterior surface of the uterus, the ovary has been turned upward so that its lateral surface was in contact with the uterus (Figs 37 and 43).

The appearance of the inside of the cyst varies in different specimens and often in different portions of the same specimen. In some instances,

nearly the entire inner surface is rough and brown owing to pigmentation from old hemorrhage. This is often true of the deeper portion of the cyst cavity (Figs. 16 and 17). In others, the lining of the cyst is for the most part smooth and gray, with or without areas of brown pigmentation or elevated red areas due to old or recent hemorrhages in the wall of the cyst. The smaller cysts of this series consisted of only one cavity while some of the larger ones were apparently multilocular with the loculi communicating with one another as though the cyst had ruptured into cystic follicles adjacent to it or there had been a fusion of several hematomas. Savage [3] has called attention to the tendency of "hemorrhagic follicles" to rupture internally into each other.

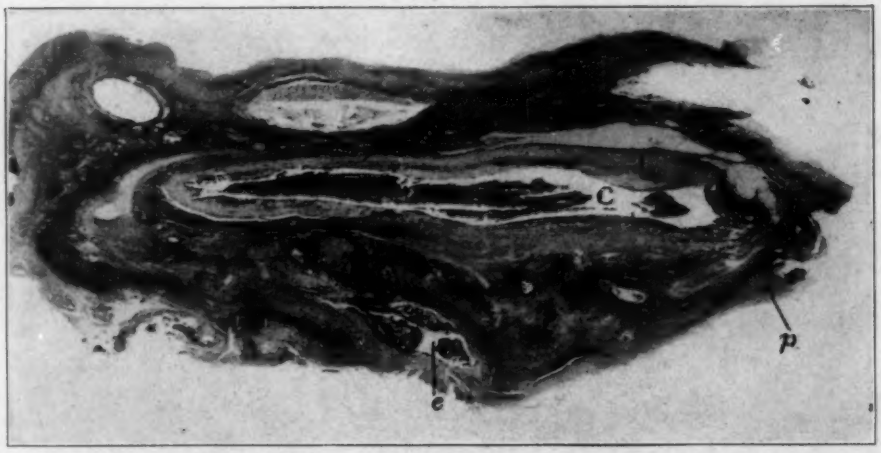


Fig. 8 (Case 10).—Enlargement (× 5) of a stained cross section of the ovary shown in the previous illustration. The cyst *c* is partially collapsed, with some of the "chocolate" contents still in its cavity. The wall of the cyst is for the most part lined by a single layer of epithelium (in places absent) which is low, cuboidal and columnar, and except near the site of perforation, lies directly on the ovarian tissue without an intervening stroma. In a few places, recent subepithelial hematomas are present and also in other places evidence of old hemorrhage as shown by pigmented cells. In the cyst wall near the site of perforation, a cellular stroma is present which contains glandlike structures lined by columnar epithelium, the picture resembling endometrium (Fig. 9). A small cyst or pocket is present lateral to the hemorrhagic cyst in which the lining more nearly resembles typical endometrium (Fig. 10).

Novak [6] has classified the various forms of ovarian hematomas thus: (1) follicular, including graafian follicle and atretic follicle; (2) corpus luteum, and, (3) stromal.

He believes that hemorrhage into atretic follicles is the most frequent form of follicular hemorrhage.

To this classification should be added a fourth variety of ovarian hematoma, namely, one lined wholly or in part by "endometrial tissue." Russell,[7] in 1899, published the report of a case in which uterine mucosa

7. Russell, W. W.: Aberrant Portions of the Müllerian Duct Found in the Ovary, Bull. Johns Hopkins Hospital **10**:8-10, 1899.

was found in an ovary. Lockyer [8] (page 328) pictures and describes a specimen of Semmelink and Joslin de Jong. The ovary was adherent to an "adenomyomatous" uterus. There was in the ovary a blood cyst lined in part by "adenomyomatous tissue" and with similar tissue in spaces in the periphery of the ovary. Casler,[9] in 1919, reported an unusual case in which a patient menstruated through the vagina after a conservative hysterectomy in which one ovary was saved. The uterus was removed for an "adenomyoma" which contained stroma but no glands. At the second operation, four years later, the enlarged ovary was removed and it was found to contain cavities lined by "normal uterine mucosa." Cullen,[10] in his recent article, "The Distribution of Adenomyomas Containing Uterine Mucosa," describes three specimens of ovaries containing uterine mucosa, one sent to him by Dr. Charles

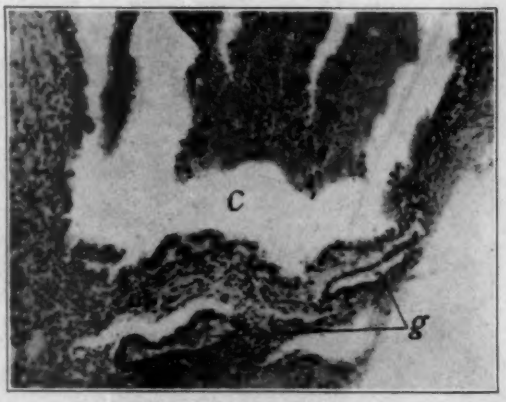


Fig. 9 (Case 10).—Photomicrograph (from another section) of the wall of the cyst *c* shown in Figure 8 near the perforation. This portion of the cyst is lined by a single layer of columnar cells resting on a cellular stroma. Glands (*g*) resembling uterine glands are also present in the stroma. *C* indicates the cavity of the cyst, and *C-C* its hemorrhagic contents. One would have little hesitation in calling this a hematoma of endometrial type and considering that the hemorrhagic contents are probably retained "menstrual" blood.

C. Norris,[11] another by Dr. Otto Schwarz, and the third of his own, the latter occurring in an ovarian cyst lined with a brownish membrane. In all these cases, the histologic picture was similar to that of normal endometrium. In the study of ovarian hematomas to determine whether or not the lining of the hematomas is of endometrial type, it would seem

8. Lockyer, Cuthbert: Fibroids and Allied Tumors, New York, The Macmillan Company, 1918.

9. Casler, D. B.: A Unique, Diffuse Uterine Tumor, Really an Adenomyoma, with Stroma, but no Glands. Menstruation After Complete Hysterectomy Due to Uterine Mucosa in Remaining Ovary, Tr. Am. Gynec. Soc. **44**:69-84, 1919.

10. Cullen, T. S.: The Distribution of Adenomyoma Containing Uterine Mucosa, Arch. Surg. **1**:215-283 (Sept.) 1920.

11. Norris, C. C.: Am. J. Obst. & Gynec. **1**:831-834 (May) 1921.

preferable to use as our standard of comparison not normal endometrium but ectopic endometrium in which there is a cyst (hematoma) formation due to the retention of "menstrual blood," similar to the condition in ovarian hematomas. We have abundant opportunity to study the variations in the appearance of the uterine mucosa in the hemorrhagic cysts or cavities, so often found in uterine "adenomyomas." These should be our standards of comparison in the study of ovarian hematomas because the physical conditions are similar. Even in the glandular hypertrophy of the mucosa lining the uterine cavity in which there is dilatation of the glands we may find these dilated glands lined by columnar, cuboidal and even low epithelium (Fig. 5). In the hemorrhagic cysts of uterine "adenomyomas," the epithelium may also be columnar, cuboidal, low, or in places it may be absent. Furthermore, in these cysts, the characteristic "endometrial stroma" may be very thin or even lacking entirely, the epithelium resting directly on the

Fig. 10 (Case 10).—Photomicrograph of a portion of the pocket *e* shown in Figure 8. Histologically, the pocket is in part lined by "endometrial" tissue.

tissue of the uterine wall or the "myoma" (Fig. 6). In the ovarian hematomas that I am reporting, the histologic appearance of the portion of the cavities lined by epithelial tissue is identical with that of the uterine hematomas above mentioned except as altered by tissue peculiar to the ovary. These questions naturally arise: What is the source of this epithelium? Are these hematomas primarily of endometrial type or may an ovarian hematoma be secondarily lined by epithelium from another source?

Both Runge [12] and Wolf [4] have demonstrated the "epithelialization" of ovarian hematomas by the invasion of the "surface epithelium of

12. Runge, E.: Ueber die Veranderunger der Ovarien bei Syncytralen Tumoren und Blasenmole; Zugleich ein Beitrag zur Histogenese, Arch. f. Gynäk. **69**:33-70, 1903.

the ovary," through the opening caused by the rupture. Runge, by serial sections made through the place of rupture, demonstrated that the epithelium lining the cyst was continuous with that covering the surface of the ovary. Wolf's work confirms that of Runge, and he states that the epithelial cells invading and relining the cavity of the cyst may be low, cuboidal or columnar; when columnar it is due to lateral compression. He also believes that glandlike structures in the underlying stroma arise from a pushing downward of the overlying epithelium.

If these cysts are of endometrial type and if their epithelial lining arises from the invasion of the surface epithelium of the ovary through

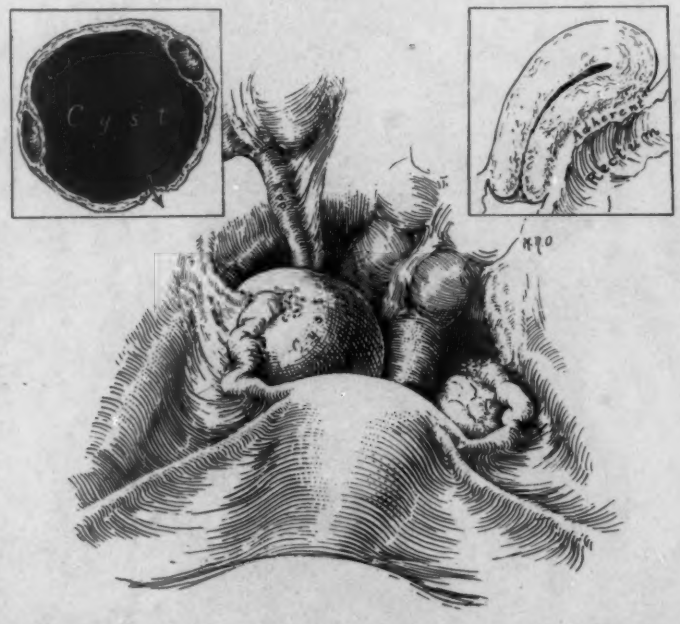


Fig. 11 (Case 5).—Perforating hemorrhagic cyst of right ovary with adherent retroverted uterus and adherent appendix. View of pelvic contents from above; × ½. The cyst of the right ovary had ruptured, causing adhesions between it and the side of the pelvis, and also between the posterior wall of the uterus and the anterior wall of the rectum. The tip of the appendix is firmly held in the pelvis by these adhesions. Only one section was made from the right ovary. This showed that the wall of the cyst in places was lined by cuboidal epithelium resting on ovarian tissue. Sections were not made from the raw areas created by freeing the uterus. Therefore, it was not determined whether or not adenoma of endometrial type was present in these tissues.

the place of rupture, we must conclude that a metaplasia of this epithelium occurs, by which it may not only assume the histologic picture of endometrial tissue but may even function as such. It may be possible that, following the rupture of the hematoma or whatever structure preceded the secondary epithelial invasion, misplaced epithelium of endometrial type was present in the periphery of the ovary at this site and this epithelium was stimulated to become invasive and reline the cavity of the hematoma. We often find glandlike structures

in the ovary, especially in its periphery, which are usually known as "cell inclusions." I believe that some of these glandlike structures are due to misplaced epithelium of endometrial type which under "proper" stimulation might become invasive and actually reline the cavity of the hematoma through the opening caused by the initial rupture, or by hemorrhage into the lumen of the gland they may develop into "endometrial" hematomas. In three patients, recently operated on by me during the menstrual period, small hemorrhagic elevations were noticed on the surface of the ovaries. These were excised or the ovary removed, and in each instance, they proved to be due to hemorrhage

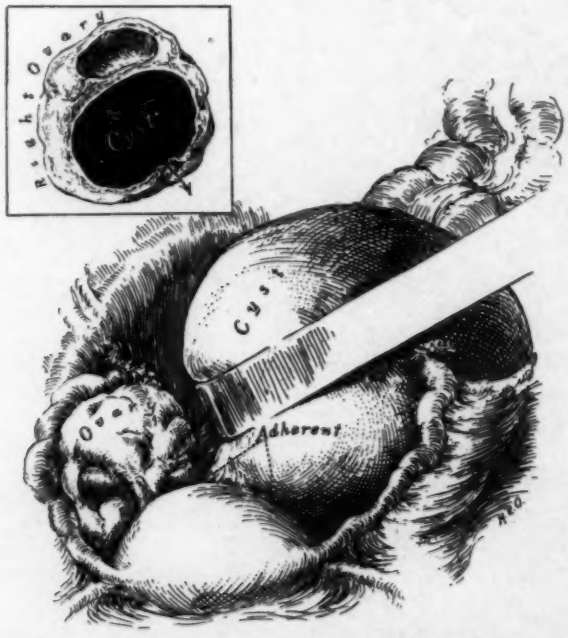


Fig. 12 (Case 9).—Perforating hemorrhagic cysts of both ovaries. View of the pelvic contents from above; × ½. The cyst of the left ovary is the largest of its kind I have seen, approximately 9 cm. in diameter. Both ovarian cysts had ruptured, the right ovary being adherent to the side of the pelvis and the left one to the posterior wall of the uterus, thus sealing their perforations. Only one section was made from each ovarian cyst, these showed that three cysts were in part lined by low to cuboidal epithleium. Pigmented cells, evidence of old hemorrhage, were also present in the walls of the cyst. Sections were not made from the cysts at the site of perforation.

about or into a space lined by tissue of endometrial type. I believe that this tissue was of endometrial type as shown both by its structure and by its function (menstruation).

In most of the specimens which I have examined it has been impossible to determine the exact nature of these cysts before the initial rupture. They may have been endometrial cysts at the start; or they may have resulted from an abnormal condition of a follicle by which a hema-

toma arose in a graafian, or atretic, follicle; or possibly following ovulation, an abnormal corpus luteum developed, due to the invasion of the epithelial tissue as above mentioned. With my present knowledge, I prefer to mention these possibilities rather than make definite statements which later may prove to be incorrect.

The cysts which I have studied histologically, twenty-six in number, may be arranged into three groups.

First, a cyst in which a portion, usually the deeper, is lined by a wavy pigmented "luteal" membrane in various stages of retrogession; while another portion of the cyst, often toward the site of perforation,

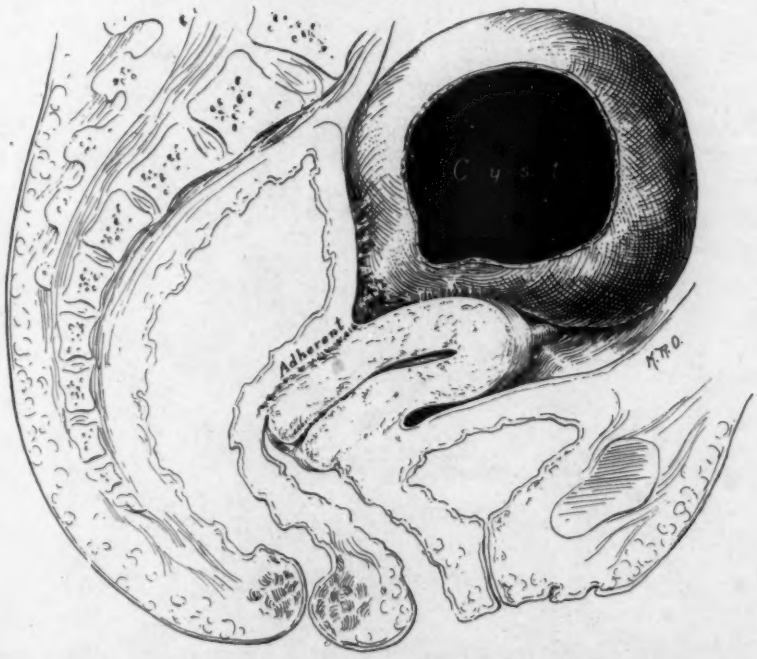


Fig. 13 (Case 9).—Sagittal section of the pelvis shown in Figure 12. The cyst of the left ovary is thin walled, the contents consist of dark hemorrhagic fluid like chocolate syrup. The anterior rectal wall is drawn forward and upward, having been firmly united to the lower half of the posterior wall of the uterus. Tissue was not removed from the posterior wall of the uterus or the anterior wall of the rectum to see whether or not adenoma of endometrial type was present.

is lined by epithelium, low, cuboidal, or columnar, resting on a vascular cellular stroma sometimes containing glandlike structures resembling uterine glands. In this stroma, one finds evidence of recent and also of old hemorrhage. The epithelial portion of the cyst strongly suggests misplaced atypical endometrial tissue both in structure and in function, namely, the evidence of periodic hemorrhage (menstruation). At the junction of the epithelial layer with the "luteal" layer the epithelium

can be seen flattened and riding up over the retrogressing "luteal" membrane (Fig. 20), also described and pictured by Wolf. With the retrogression of the "luteal" layer and the advance of the epithelial lining, the hematoma may be gradually converted into a hematoma completely lined by epithelium of the endometrial type. This group represents either the development of an "endometrial" cyst from the invasion of a follicular hematoma by misplaced "endometrial" epithelium or else it represents the regeneration of the epithelial lining of an "endometrial" cyst after a hemorrhage (menstrual), as indicated by the contents of the cyst, the pigmented "luteal" layer and the lesions in the pelvis. A good example of this group is shown in Figure 17.

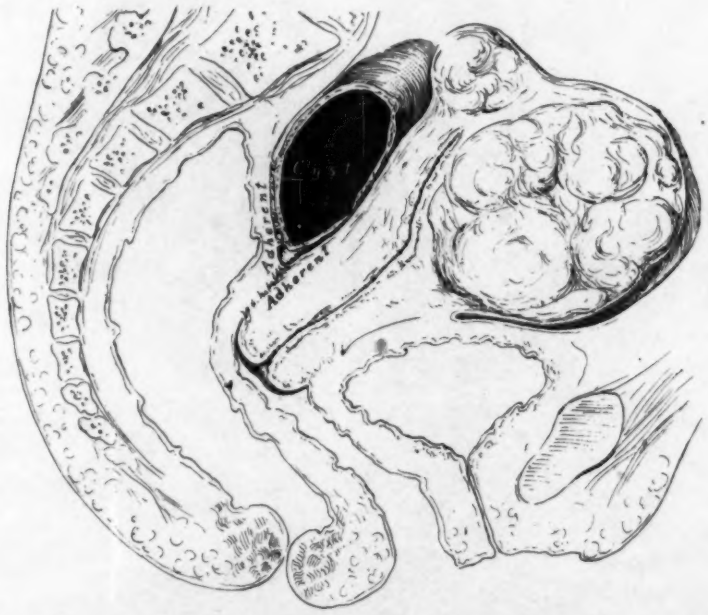


Fig. 14 (Case 8).—Perforating hemorrhagic cyst of left ovary, multinodular myomatous uterus, supravaginal portion of the cervix densely adherent to the anterior wall of the rectum. Sagittal section of the pelvis; × ½. The cyst had ruptured and the perforation was sealed by the posterior wall of the uterus to which the cyst had become adherent. Some of the contents of the cyst had escaped into the culdesac causing dense adhesions between the anterior rectal wall and the supravaginal portion of the cervix. The rectum is drawn upward and forward by these adhesions. Tissue from the posterior wall of the uterus was not examined to determine whether or not adenoma of endometrial type was present.

The second group may represent a later, or even an earlier, stage of the preceding. The cyst is lined by epithelium, low, cuboidal or columnar, often with a narrow, underlying, vascular stroma with occasional glandlike structures, most evident about the site of perforation. The entire cyst is like the epithelial portion of the cysts described in the first group. The picture suggests periodic hemorrhages in the recent hematomas in the subepithelial stroma and in the pigmented

cells in the same situation. A good example of this group is shown in Figure 28. All gradations between the first two groups may be found.

The third group (well shown in Figures 2, 3 and 4), and the smaller one, is more difficult to recognize as an ovarian hematoma of endometrial type. The cyst wall is composed of ovarian tissue which lacks a vascular stroma and in places may also lack a definite epithelial lining. When the latter is present, it is usually low to cuboidal and rests directly on the ovarian tissue. However, tissue of endometrial type is present in pockets in the periphery of the ovary about the perfora-

Fig. 15 (Case 4).—Perforating hemorrhagic cyst of the left ovary; multinodular myomatous uterus; "adenomyoma" in the right uterine cornu; adhesions; encapsulated cyst contents in the culdesac. Cross section of the pelvis; × ½. The cyst was badly torn in removing it, and the representation of pelvic contents was drawn from a sketch made just after the operation. Sections were not taken from the raw areas caused by the escape of the contents of the cyst and those made from the cyst were unsatisfactory.

tion. The exact counterpart of the lining of this ovarian hematoma may be found in some of the uterine hematomas occurring in "adenomyoma" of the uterus (compare Figures 3 and 6).

In studying any one of these cysts, certain questions naturally arise regarding the various stages in the development of the cyst prior to the present one and what would be its future stages if it had not been removed. Apparently, these cysts have a definite life history, with

variations, in which they pass through various stages of growth or development to be followed by various stages of retrogression by which the smaller cysts may "disappear" as they are apparently rare after the menopause. It is difficult to determine the duration of their life in any case. I believe it varies greatly in different cases and is not

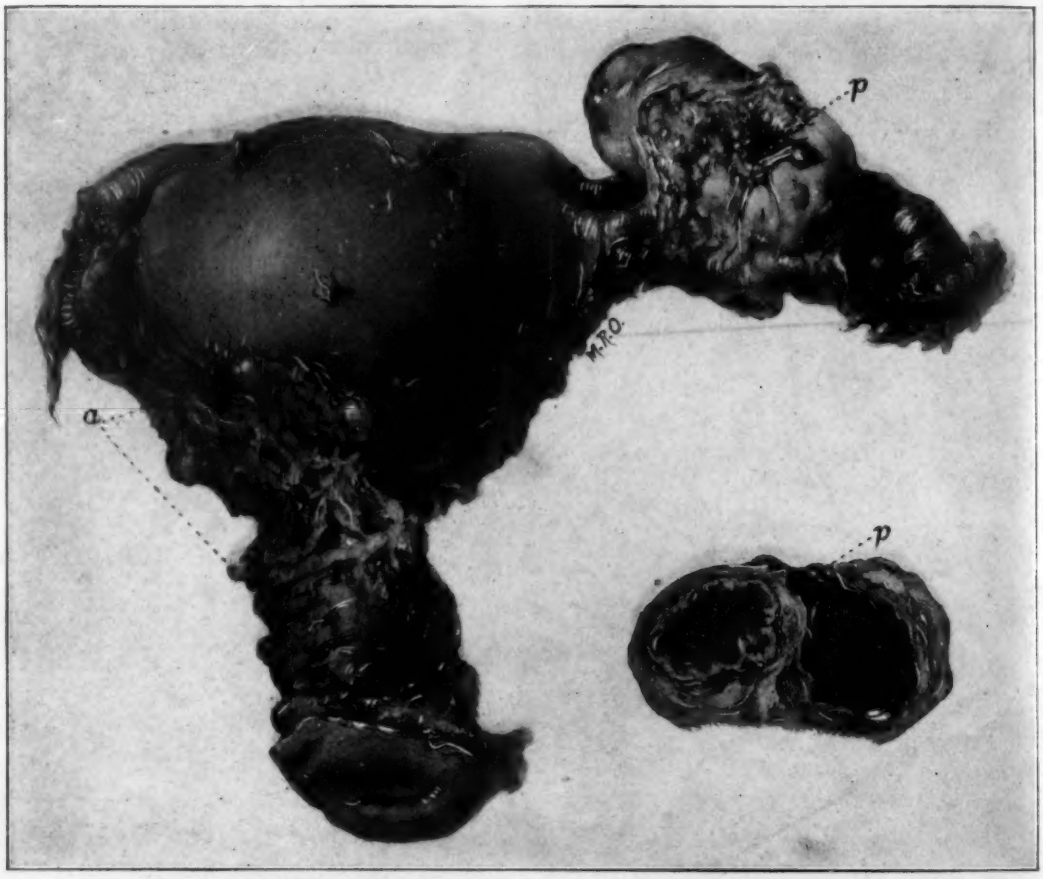


Fig. 16 (Case 21).—Perforating hemorrhagic cyst of right ovary; adenoma of endometrial type of the culdesac invading the posterior uterine wall and uniting it to the rectum. Posterior view of the uterus, right tube and ovary; × 1. Ovary is shown turned upward, with perforation on its lateral surface. A raw area is present about the site of perforation due to freeing the ovary from the side of the pelvis to which it was adherent. Longitudinal section of the ovary shows a corpus luteum in the proximal pole and a hemorrhagic cyst in the other. For microscopic sections of the cyst, see Figures 17, 18, 19 and 20. Adenoma of endometrial type, with discrete "adenomyoma" in places, were present in the greater portion of the raw area of the posterior wall of the uterus. Sections through the nodule indicated in the short "arm" of the "pointer" a apparently demonstrate the development of "adenomyoma" of the uterus from epithelium deposited on its peritoneal surface by the escape of the contents of the perforating hemorrhagic ovarian cyst into the culdesac (Figs. 21, 22, 23, 24 and 25).

necessarily of long duration. I hesitate to state what I believe their life history to be because I am not sure that I am correct. It is true that we may possibly be dealing with several different kinds of cysts,

but it is much more likely that most of the apparent different kinds represent various stages of growth or of phases (menstrual) in the life history of one variety.

One of the most interesting features associated with the ovaries containing these cysts is the clefts or pockets sometimes simulating small cysts, lined by epithelial tissue. These pockets are small and situated about the perforation, or they may be lateral to it. I have always found them on the lateral surface of the ovary or on its free border. The pockets are lined by epithelium of endometrial type and function; and the type may be more nearly normal than that lining its

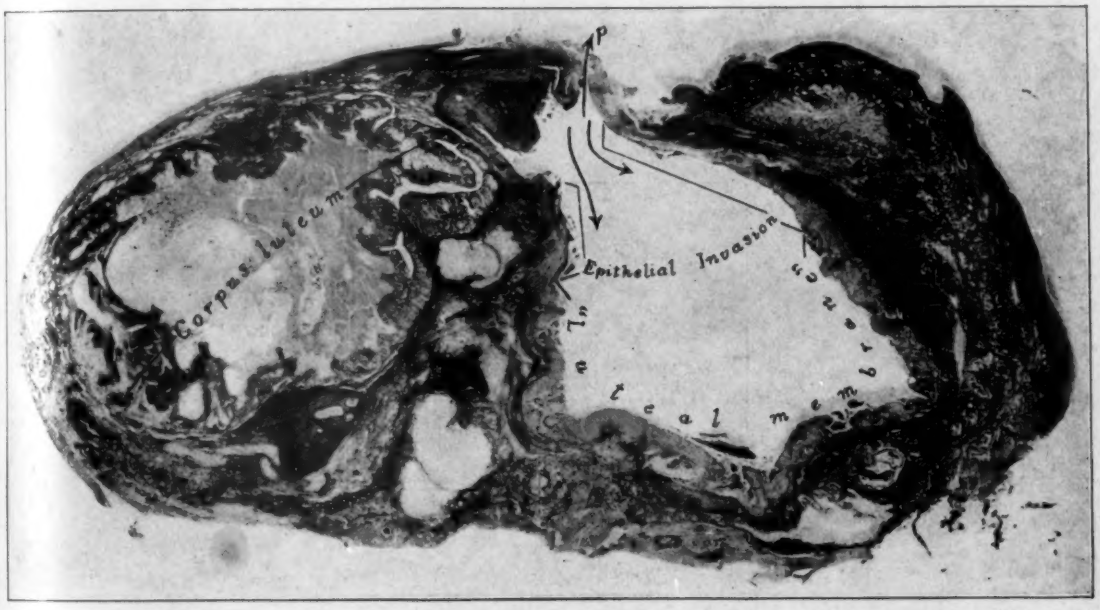


Fig. 17 (Case 21).—Enlargement (× 3) of a stained longitudinal section of the ovary. The deeper portion of the hemorrhagic cyst is lined by a thick, wavy, pigmented membrane. The rest of the cyst (toward the perforation) is lined by a single layer of columnar cells separated from the underlying ovarian tissue by a vascular stroma (Fig. 19). As the latter cyst lining approaches the pigmented "luteal" layer, its surface epithelium (now cuboidal or flattened) extends over the surface of the retrogressing "luteal" layer (Fig. 20). Tissue resembling typical endometrium (Fig. 18) is present both in the torn ovarian tissue within the perforation and in depressions on the surface of the ovary outside. Two interpretations of the picture could be made: first, following the initial perforation of the ovarian hematoma, epithelium of endometrial type situated in the ovary at the site of perforation was stimulated to invade the cyst and is gradually relining its cavity and converting it into an "endometrial" cystoma; or secondly, it represents the regeneration of the epithelial lining of an endometrial cyst after hemorrhage as indicated by the contents of the cyst, the pigmented "luteal" layer and the lesions in the pelvis.

associated hematoma (Figs. 4, 10, 30 and 58). Both the hematoma and the clefts or pockets are apparently part of the same process. The stimulus which causes the epithelial invasion of the hematoma or the development of an "endometrial" cyst also apparently causes the development of the clefts or pockets.

All phases of the hemorrhagic (menstrual) cycle may be observed in these hematomas and often in one hematoma. I judge the process of repair is not so rapid as in the mucosa of the uterine cavity, and the repeated hemorrhages may eventually destroy the cyst. The same hemorrhagic cycle may take place in the clefts or pockets as in the cyst proper. A "premenstrual" condition is well shown in Figure 28, as the patient was operated on the day that menstruation was due. Hemorrhage is present in the entire subepithelial stroma of the larger cyst and likewise in the clefts and pockets in the periphery of the ovary. All of the "endometrial" tissues of the ovary had responded to the "menstrual" impulse.

Evidence of old hemorrhage may be found in the pigmented cells in the subepithelial stroma of some of the cysts. As the "menstrual" process in these cysts is similar to that of the uterine mucosa the blood escapes into the cyst cavity by the rupture of the subepithelial hematomas. One can also see how "menstrual" blood might at times

Fig. 18 (Case 21).—Photomicrograph of tissue in the wall of cyst at the site of perforation. Histologically, it resembles endometrium.

escape into the pelvis; either leak by the site of the original perforation; from a secondary perforation or from the endometrial tissue in the clefts or pockets. The "menstrual" blood escaping into the peritoneal cavity may carry with it some of the epithelium lining the cyst cavity, or similar tissue may escape from the endometrial pockets in the periphery of the ovary about the perforation. This epithelium may become implanted in the culdesac or other portions of the pelvis and there give rise to other foci of "endometrial" tissue. The mechanism of secondary perforations of the cyst can be easily explained by a subepithelial hematoma developing in a thin portion of the cyst, the rupture of the hematoma so weakening the wall of the cyst that a perforation would occur.

B. *The Adhesions Arising from the Escape of the Contents of These Cysts.*—I judge that the amount of the cyst contents escaping into the peritoneal cavity is usually small, and clinically, it is rarely accompanied by any subjective symptoms.

The adhesions occur about the ovary at the site of perforation and in different portions of the pelvis where there are naturally folds or pockets in which such material would be apt to lodge, as has been previously stated in this paper. They vary greatly in degree and extent and may be slight, as those resulting from a mild peritonitis of tubal origin or so dense as to simulate malignancy.

Savage [3] has described these adhesions and believed that they arose from a reactive inflammation due to the escape of the hemorrhagic contents of the cyst. Hedley [5] has also described them and mentioned one case in which there was such a marked inflammation of the cellular tissue of the culdesac as to lead to a diagnosis of cancer of the rectum. He obtained a pure culture of *Staphylococcus pyogenes albus* in two

Fig. 19 (Case 21).—Photomicrograph of the wall of the cyst being relined or regenerated by the invasion of epithelium from the periphery of the ovary through its perforation or from epithelium not removed by the hemorrhage (Fig. 17). Histologically, the portion of the cyst marked "epithelial invasion" (Fig. 17) is lined by a single layer of epithelium with a vascular underlying stroma, in places containing pigmented cells evidence of past hemorrhages and in other places fresh blood evidence of a recent hemorrhage.

cases and suggests this organism as a cause. Both Savage and Hedley call attention to the lack of gross evidence of tubal inflammatory disease.

I began to study the cause of these adhesions in the year 1918. Cultures were made both from the cyst contents and also from the pelvic cavity after freeing the adherent structures. Eight cases have been studied in this manner, and the cultures were sterile in all. Agar and blood serum were used as culture mediums. Dr. George S. Graham, in 1918, injected some of the material, obtained aseptically from these cysts, into the peritoneal cavity of rabbits. It caused adhesions. This experiment was performed only in a few instances and was not controlled by injecting normal human blood.

I had planned to present a paper at the last meeting of the American Gynecological Society describing these cysts and the adhesions resulting from them. Some of the illustrations in the present paper were made from sketches prepared for the paper I had planned to read a year ago. At that time I believed that these cysts were "endometrial" hematomas and that the adhesions arose from the escape of "menstrual" blood into the peritoneal cavity. It differed from normal blood in that it was very irritating, and I thought that the irritation was probably due to some "digestive ferment." I still believe that these cysts are hematomas of endometrial type and their contents may be very irritating to the peritoneum. Up to that time, I had observed three patients with these cysts in which an "adenomyoma" of the posterior uterine wall was also present (Cases 2, 3 and 6 of this paper). The "adenomyomas"

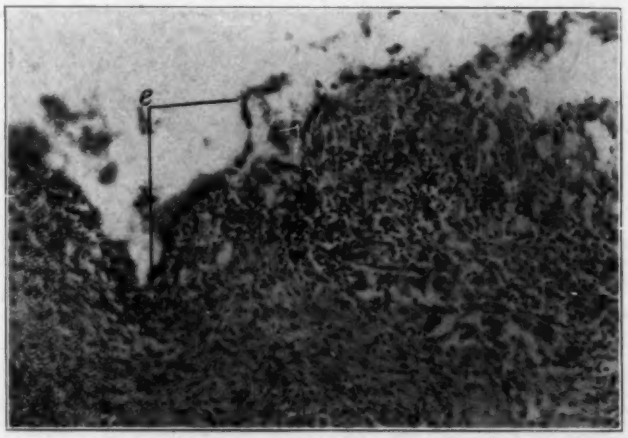


Fig. 20 (Case 21).—Photomicrograph of the wall of the cyst (Fig. 17) at the junction of the "epithelial" and "luteal" lining. The epithelial cells lining the portion of the cyst shown in Figure 19 have become cuboidal and flattened and can be seen extending (growing) over the retrogressing "luteal" layer. The "luteal" layer lacks an epithelial covering; and also the fibrous tissue lining found in typical corpus luteum hematomas. In time this cyst might be completely lined by "endometrial" epithelium as those shown in Figures 28 and 39.

had "apparently" extended through the peritoneal surface of the posterior uterine wall and obliterated the culdesac, fusing the uterus with the rectum. The "adenomyomas" were apparently not continuous with the mucosa of the uterine cavity. I considered these three cases as further proof that the ovarian hematomas associated with them were of endometrial type. Developmental anomalies are often multiple and at that time I regarded these as instances of misplaced "endometrial" tissue in both the ovary and the posterior wall of the uterus. The adhesions between the uterus and the rectum in these three cases were identical in character with other cases of perforating hemorrhagic cysts in which "adenomyoma" had not been observed. The tissue

involved in the adhesions in the latter cases had not been examined under the microscope and therefore adenoma cannot be excluded. I thought that the adhesions in the three cases arose, at least, in part, from the rupture of superficial subperitoneal "adenomyomatous" spaces of the uterine wall which had become overdistended with menstrual blood. This also afforded an opportunity for the invasion of the anterior rectal wall and offered an explanation of the development of "adenomyoma" in the rectogenital space. Sections made of the posterior uterine wall show the adenomyomatous spaces which had been torn open in freeing the uterus from the rectum (Fig. 63).

During the last year, I have examined microscopically all tissue involved in these adhesions except when conservative work was done. Adenoma of the edometrial type was found in this tissue in ten of the fourteen patients with perforating hemorrhagic cysts of the ovary

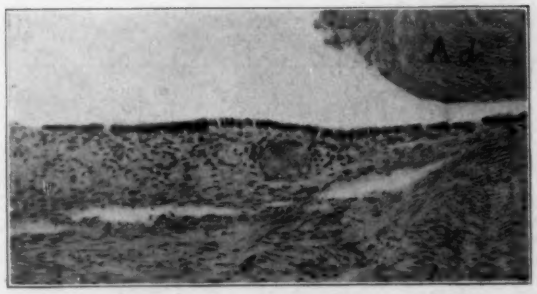


Fig. 21 (Case 21).—Photomicrograph of the posterior surface of the uterine wall near the nodule indicated in Figure 16. The surface of the uterus is here covered by columnar epithelium with an underlyng vascular stroma similar to that shown in the "relining" of the ovarian hematoma by the "epithelial invasion" (Fig. 19). *"Ad"* represents an adhesion on the surface of the uterus. This change in the surface of the uterus is due to the escape of the contents of the cyst into the culdesac. Does it represent an epithelial implantation carried with the contents of the cyst or an "endothelial" metaplasia from the "specific" irritation of the cyst contents on the peritoneal covering of the uterus? I believe the former.

operated on by me from May 1, 1920, until May 1, 1921. In the four cases in which it was not found, the adhesions were slight, conservative work was done and the tissue involved outside the ovary was not removed. During the month of May of this year, I operated on four patients with these cysts, and in all four adenoma of endometrial type was found in the pelvic tissue outside the ovary. These four specimens have not been sufficiently studied to be included in this paper. Of the twenty-three cases reported in this paper, pelvic adenoma of endometrial type was found in thirteen. In the remaining ten it was not found. I believe it might have been found in many, and possibly in all, of these ten cases had the tissue involved in the adhesions been carefully studied. It was examined microscopically in only one of these, and in that one not thoroughly enough to exclude adenoma.

All of the twenty-three cases reported in this paper were of value in the study of the clinical features of this condition, and in most of them a satisfactory histologic examination of the ovaries was made.

Only the thirteen cases in which the tissue involved in the adhesions was examined histologically and adenoma was found will be considered in the following discussion.

These cases may be grouped according to the distribution of the adhesions as follows:

1. Extensive adhesions in the culdesac obliterating the lower portion of it and uniting the cervix or the lower portion of the uterus to the rectum; with adenoma of the endometrial type invading the cervical and the uterine tissues and probably also (but to a lesser degree) the anterior wall of the rectum.

2. Adhesions between the uterus and the rectum with multiple discrete invasions of the posterior uterine wall by adenoma of the endometrial type.

Fig. 22 (Case 21).—Photomicrograph from another portion of the section shown in Figure 21. The epithelium is "sinking" into the underlying vascular stroma forming a dilated gland or bleb, apparently the second step in one form of development of adenoma of the endometrial type on the surface of the uterus.

3. Adhesions in the normal peritoneal folds associated with the development of adenoma of endometrial type, as, about the uterosacral ligaments; on the posterior surface of the broad ligaments between the tube and the ovarian ligament; on the anterior surface of the broad ligament between the tube and the round ligament, and in the vesico-uterine reflection of peritoneum.

4. Discrete nodules of adenoma in the wall of the rectum and sigmoid.

To describe in detail the conditions found in these thirteen cases would be but a repetition of the legends accompanying the illustrations and it would not be done so well.

Group I. Extensive adhesions in the culdesac uniting the cervix or uterus or both to the rectum with adenoma of endometrial type, is represented in nine cases (Cases 2, 3, 6, 12, 13, 15, 19, 21 and 23).

In this group the material from the cyst escaping into the culdesac caused adhesions between the cervix or uterus and the rectum. The adenoma of endometrial type apparently develops on the surface of the adherent structures (Figs. 21, 22, 23 and 24), between the adhesions, especially on the posterior surface of the uterus or cervix, and later may become invasive. The cervix or uterus is invaded more often, and usually to a greater extent than the other adherent structures (Figs. 59, 61, 36, 26, 34, 42, 62 and 64). Possibly uterine tissue "attracts" the adenoma; it is better suited for its growth. In some instances, the adenoma penetrates the uterus with very little reaction on the part of the tissue involved (Fig. 59). In others, the reaction is great, causing a diffuse or localized thickening, namely, an "adenomyoma" (Figs. 38, 44, 62 and 64). Adenoma may also be present in the tissues which are adherent to the ovary (Figs. 44, 45 and 51).

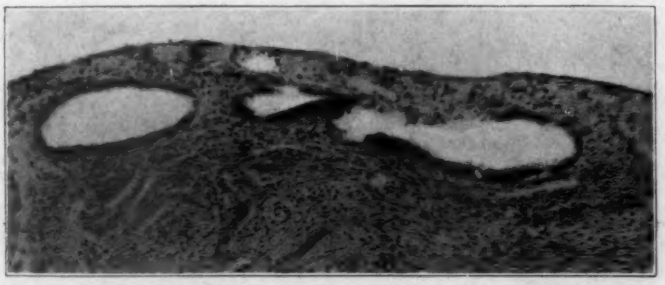

Fig. 23 (Case 21).—Photomicrograph from another portion of the section shown in Figure 21. The dilated glands are completely embedded in the vascular stroma, which is thicker, apparently a third stage in one form of development of adenoma of endometrial type on the surface of the uterus.

The epithelial lining of the ovarian hematomas, of the clefts and pockets on the surface of the ovary is similar to that of the adenoma in the tissues to which the ovary is adherent and in the adherent structures in the culdesac (Figs. 39, 40 and 41). The process in all is apparently the same whether in the ovary, in the cystlike cavities of the adenoma of the uterus, cervix, large intestine or in any other tissue, but is altered by the tissues involved and by physical factors caused by the retention of "menstrual" blood.

The question naturally rises, Which is primary? The study of my material has convinced me that the ovary is the primary site. Two methods of extension of the "endometrial" adenoma must be considered. First, extension, of the growth by continuity, and in some of the specimens, this may have occurred, and the second is by the implantation of epithelial cells carried with the contents of the cyst or from the epithelial clefts and pockets in the ovary. The implantation is

analogous to the implantation of papilloma and cancer in the culdesac from the rupture of ovarian cysts containing these growths. The question of the origin of these secondary growths from metaplasia of the peritoneal endothelium due to the irritating action of the contents of the cyst will be considered later.

Group II. Peritoneal adhesions with multiple localized invasions of the uterine wall by adenoma.

This phenomenon was also observed in one of the cases of Group I (Case 21, Fig. 25). It was well demonstrated in Case 17, in which discrete "adenomyomas" were found in the posterior uterine wall beneath and about the adherent left ovarian hematoma (Figs. 44 and 46) and also the adenoma invading the uterine wall beneath the adherent right ovarian hematoma (Figs. 44 and 45).

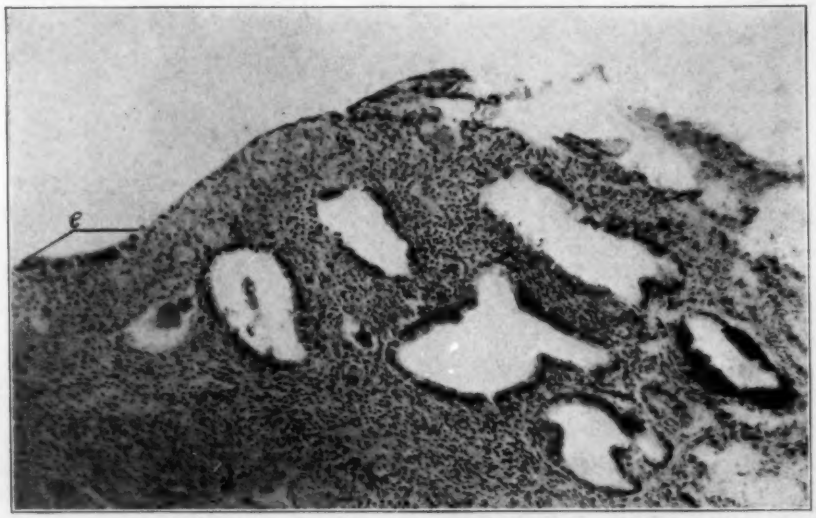


Fig. 24 (Case 21).—Photomicrograph from another portion of the section shown in Figure 21. There is a marked hypertrophy of both the glands and the stroma forming an elevation on the surface of the uterus. Columnar epithelium is present on the surface *e* as in Figure 21. This picture apparently represents a still later stage of development of the adenoma and is similar to the condition shown in Figure 41 (Case 15).

Group III. Adhesion in the normal peritoneal folds of the pelvis associated with the development of adenoma of endometrial type in this tissue, as, about the uterosacral ligament; on the posterior surface of the broad ligament between the tube and ovarian ligament; on the anterior surface of the broad ligament between the tube and the round ligament; in the vesico-uterine reflection of peritoneum and other similar folds where the contents of the ovarian cyst would be apt to lodge. There were two cases in this group, Cases 20 and 22. The illustrations, with their legends, of the specimens from these two cases

picture the conditions found better than any verbal description (Case 20, Figs. 71, 73 and 74, and Case 22, Figs. 65, 67, 68 and 69). There were three interesting conditions found in the specimens of these two cases.

One is the lesion present about the left uterosacral ligament in Case 20 (Figs. 71 and 72). There is a localized thickening of the peritoneum with puckering about its edges, and in this thickened area can be seen small pigment elevations, the surface of small cysts containing "old blood" (Fig. 72). Histologically, these cysts are small hematomas of endometrial type (Fig. 74). The second lesion is that occurring in definite peritoneal folds where the surfaces are adherent

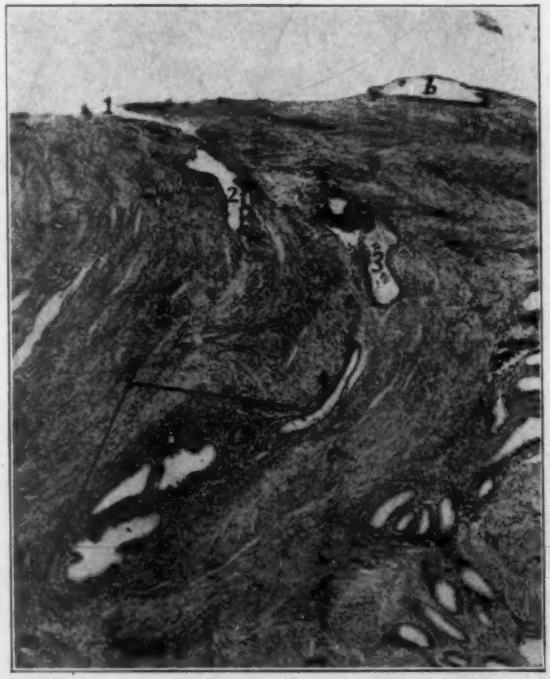


Fig. 25 (Case 21).—Photomicrograph from another portion of the same section as the preceding (lower power). *B* is the small dilated gland or bleb shown in Figure 22. At 1 is the remains of epithelial tissue which had been almost completely "rubbed off" in removing the uterus. 1, 2, 3, 4 and 5 represent the invasion of the uterine wall by the adenoma. There is a marked (reaction) hypertrophy of the uterine tissue forming an "adenomyoma." This represents the final stage in the origin of "adenomyoma" of the uterus from epithelium deposited on its surface from the contents of a perforating hemorrhagic cyst of the ovary.

and an adenoma of endometrial type has developed (Figs. 65, 67 and 68). The adenoma developing in the adherent fold of peritoneum between the left round ligament and the anterior surface of the broad ligament had invaded the round ligament giving rise to an "adenomyoma" of that structure (Fig. 69). The third lesion is still more interesting, that is, blebs or small peritoneal cysts, some containing blood, scat-

tered over different portions of the specimen especially about the lesions in the adherent peritoneal folds (Fig. 68). Histologically many of these blebs are cystomas of endometrial type (Fig. 70). These blebs or cysts are very similar to the one shown in a pocket on the surface of the ovary near the perforation of the hematoma (Case 23, Fig. 50), and also in the development of adenoma on the surface of the uterus (Case 21, Fig. 22). The advocates of the serosal theory of the origin of adenomyoma would look on these specimens as supporting their views on the subject. A full discussion of this phase of the subject may be found in Lockyer's [8] work on fibroids and allied tumors, in his presentation of the serosal theory and his chapter on extra-uterine "adeno-

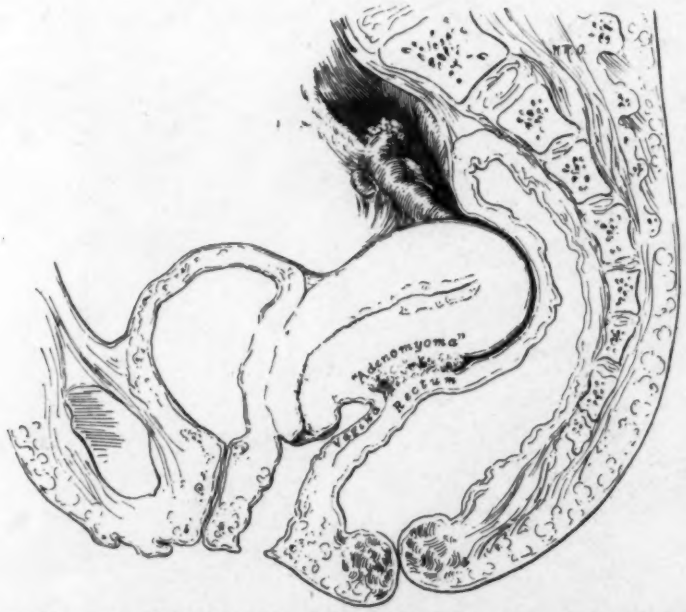


Fig. 26 (Case 21).—Sagittal section of the pelvis showing the relation of the culdesac adenoma of endometrial type to the uterus and rectum prior to operation; × ½. The adenoma arsing in the culdesac "due to the escape of the contents of the cyst" has invaded the posterior wall of the uterus forming an "adenomyoma" and has united this portion of the uterus to the rectum posteriorly. One can see how this growth might extend posteriorly through the wall of the rectum or down between the rectum and vagina or through the vagina presenting in the vaginal vault behind the cervix as in Figure 52, Case 24.

myoma." On pages 295 and 296, Lockyer expresses the following views of the advocates of this theory: "Heterotopy of serosal epithelium is the probable explanation of the existence of the epithelial spaces and cysts in most of the extra-uterine swellings found between the rectum and genital tract," and again he states that "it has also been conclusively shown that the connective tissue which surrounds the 'endothelial' inclusions can be excited to hyperplasia which causes it to assume the characteristic histological features of the stroma of the uterine mucosa."

Group IV. Discrete nodules of adenoma in the wall of the rectum or sigmoid.

These occurred in two cases (Cases 12 and 19). In Case 12 it was situated in the anterior wall of the rectum back of the adherent uterus (Fig. 62). It was distinctly palpated on rectal examination prior to the operation. The rectal mucosa was freely movable over it. It was also palpated during the operation but was not excised. A positive statement cannot be made as to whether or not adenoma was present. The patient was operated on, June 5, 1920. I examined her, May 23, 1921, and was able to detect it; but it had decreased in size

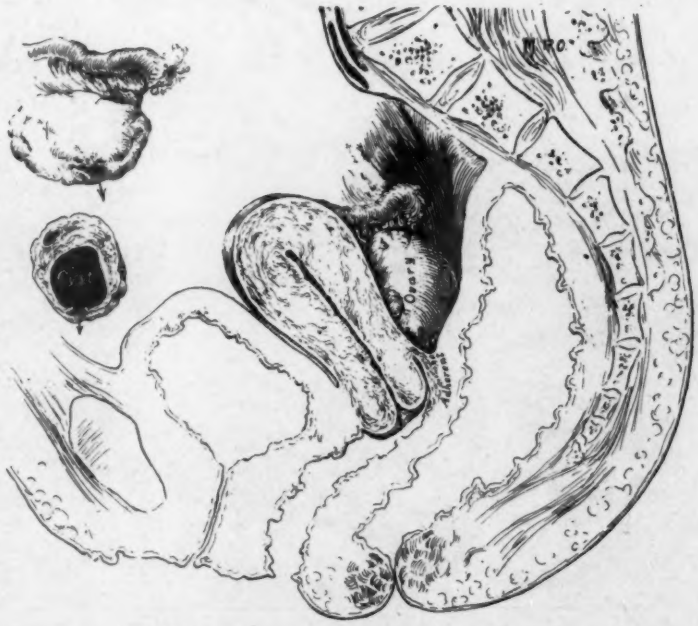

Fig. 27 (Case 13).—Perforating hemorrhagic cyst of the right ovary; ovary prolapsed and adherent; anterior wall of the rectum drawn forward by adhesions between it and the pelvic portion of the vagina. Sagittal section of the pelvis (× ½) showing the condition found at the first operation, June 28, 1920. Prior to the operation a small thickened area was palpated in the culdesac between the cervix and rectum. At operation, the right tube and ovary and the appendix were removed. Before leaving the hospital this thickened area was detected, and I realized that I had probably overlooked an adenoma of the endometrial type in the culdesac.

probably due to the cessation of ovarian function, as both ovaries and the entire uterus had been removed. The second case (Case 19) was even more interesting. In addition to the adenoma of endometrial type of both ovaries (Fig. 54), and the posterior uterine wall (Figs. 55 and 59), two distinct nodules were palpated in the sigmoid. The upper one was not in contact with the adhesions about the ovaries and the uterus. The upper nodule was the larger and was excised, and the intestine was repaired by an end-to-end suture. Sections of this nodule showed

that the adenoma had extended through the wall of the intestine into the submucosa and there formed small cysts dilated with "menstrual" blood. Adenoma of endometrial type was found on the serous surface of the sigmoid beneath an epiploic appendage and in all the coats of intestine to, and including, the submucosa. Apparently some of the contents escaping from the ovarian hematoma had carried with them some of its epithelium, which was deposited on the surface of the sigmoid and later invaded it. The further description of this case will be reported in another paper. The lower and smaller nodule was not excised. The patient made a satisfactory recovery and so far has remained well. I am waiting with great interest to see whether

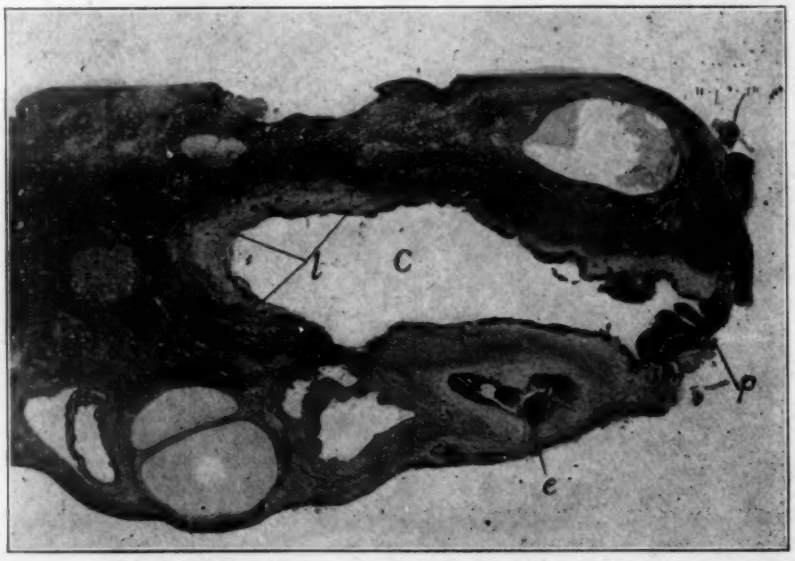


Fig. 28 (Case 13).—Enlargement (× 5) of a stained cross section of the ovary through the site of perforation. Patient expected to menstruate the day of the operation. It, therefore, represents a "premenstrual" condition. The chief features of interest are the larger collapsed hemorrhagic cyst *c*, the small cyst or pocket *e* (Fig. 30) and the ovarian tissue about the site of perforation *p* (Fig. 32). The wall of the cyst *c* is lined by epithelium, for the most part cuboidal, in places columnar, with a cellular stroma containing recent (premenstrual) hemorrhage which appears black in the picture. The columnar epithelial is most marked near the site of perforation where definite glandlike structures are present resembling uterine glands in cross section (Fig. 29).

or not the "adenoma" left in the sigmoid will cause her any further trouble. Both ovaries and the entire uterus were removed and I hope and expect that the cessation of ovarian function will cause any adenomatous tissue which was left in the pelvis to atrophy.

I believe that a large percentage, and possibly all, of the ovarian hematomas reported in this paper were of endometrial type. The microscopic findings in all those examined showed in places a lining

which resembled the lining of hematomas found in "adenomyomas" of the uterus, which apparently had arisen from the mucosa of the uterine cavity. The most typical endometrial formation was found in the portions of the hematomas about the site of perforation and in pockets or clefts in the periphery of the ovary about the same site. This would be expected, as in these situations the epithelial growth is not subjected to the pressure which is present in the hematoma proper. The hemorrhagic feature of these cysts is similar to that of menstruation both in its gross manifestations and in the presence of subepithelial hematomas in the lining of the cyst, with evidence of rupture into its cavity. The hematomas manifest their activity during the menstrual life of the patient as does also the uterine mucosa. In two patients operated on at the time of the menstrual period, one the day that menstruation was due (Case 13, Fig. 29) and the other the last day

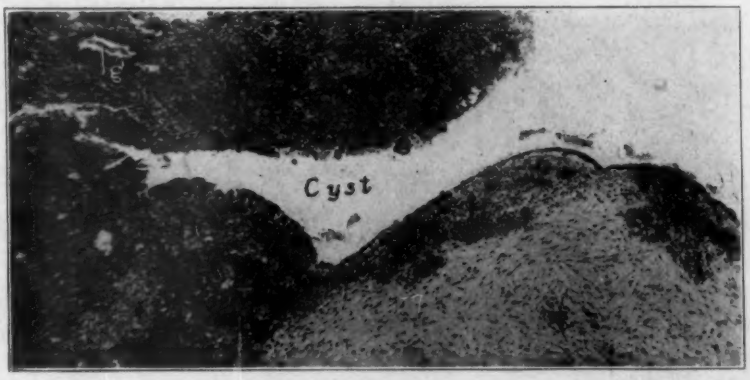


Fig. 29 (Case 13).—Photomicrograph of the wall of the cyst shown in Figure 28, *c*, near the site of perforation. The cyst is lined by cuboidal and columnar epithelium with moderate and extensive subepithelial hemorrhage (premenstrual). A structure resembling a uterine gland is present at *g*. The cyst is an ovarian hematoma of endometrial type.

of menstruation (Case 19, Fig. 57), the histologic changes in the ovarian "endometrial" tissue corresponded to the phase of the menstrual cycle indicated by the menstrual history of the patient. The contents of the ovarian hematomas resemble old menstrual blood. The most important evidence that these ovarian hematomas and clefts or pockets are of endometrial type is the secondary development of adenoma of endometrial type in the tissues or structures which have become "infected" by material escaping from them. The adenoma in these secondary pelvic foci may more closely resemble normal uterine mucosa than the original ovarian condition and may, in importance, overshadow the latter. "Menstruation" occurs in these pelvic foci and they may be the source of a further extension of the growth, just as it extended from the ovary.

From the standpoint of its origin, "adenomyoma" of the uterus may be divided into at least two groups:

1. The generally recognized group in which the growth has apparently arisen from an invasion of the uterine wall by the mucosa lining the uterine cavity, namely, invasion from "within" the uterus.

2. "Adenomyoma" arising from the invasion of the serous surface of the uterus by adenoma of the endometrial type secondary to adenoma of the ovary, namely, invasion from "without" the uterus. Histologically, the two tumors are identical. The advanced stage of the latter may very closely resemble the former in its gross appearance (Figs. 62 and 64). I presume that it is possible for the adenoma arising on the surface of the uterus to penetrate the entire wall and even reach the mucosa lining the uterine cavity.

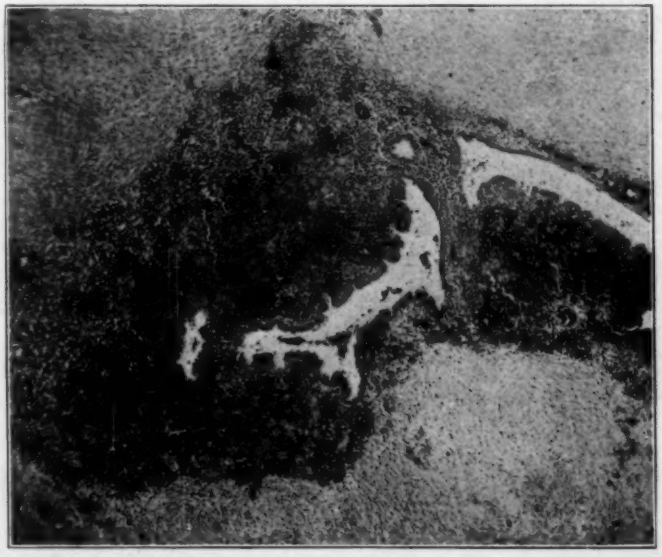

Fig. 30 (Case 13).—Photomicrograph of a portion of the small pocket shown at *e* (Fig. 28). The pocket is lined by columnar epithelium with extensive "premenstrual" hemorrhage in the underlying stroma (appearing black). The pocket is lined by tissue of endometrial type.

I do not know whether or not there is a third group of "adenomyoma" arising from misplaced endometrial tissue in the uterine wall or by invasion from "without" from other sources than the ovary.

Granted that these ovarian hematomas may give rise to secondary growths of adenoma of endometrial type in the pelvis, this question naturally arises, Are all ectopic pelvic adenomas of endometrial type secondary to a similar condition in the ovary? I cannot answer this question. The origin of "adenomyoma" of the uterus from the mucosa of the uterine cavity has just been mentioned. Do we find these

hematomas of the ovary in all other instances of ectopic pelvic adenoma of uterine type? In the thirteen cases of ectopic adenoma reported in this paper, hematoma of the ovary or ovaries in various stages of development and retrogression were found in all, and also in the four patients operated on by me during the month of May of this year and not included in this report. During the year, May 1, 1920, to May 1 1921, I operated on two patients with pelvic adenoma of endometrial type without gross evidence of hematoma of the ovaries. In both instances, a small area of thickening of the peritoneum was found in the culdesac. In this area, small cysts were present which were lined by columnar epithelium and a stroma resembling endometrial tissue—conditions similar to that shown in Figs. 71, 72 and 74. There was a puckered area on the lateral surface of one of the ovaries in

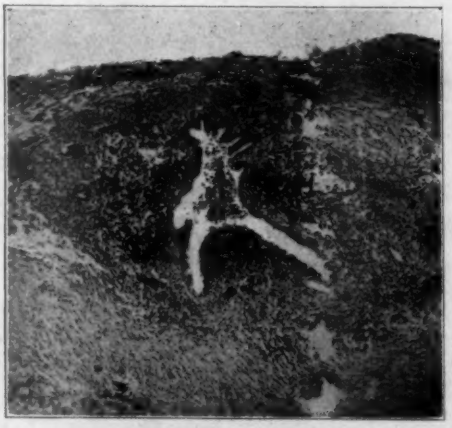

Fig. 31 (Case 13).—Photomicrograph of a dilated "gland" of endometrial type in the periphery of the ovary just above the pocket *e* (Fig. 28). Premenstrual hemorrhage (*H*) is present in the stroma about the "gland." All the "endometrial" tissue in the ovary had apparently reacted to the "menstrual" impulse.

each case, which on microscopic section showed a space in the periphery of the ovary lined by columnar epithelium and stroma resembling endometrial tissue. These spaces of endometrial type could be interpreted as the remains of an "endometrial" hematoma in which nearly complete retrogression had occurred or "endometrial" pockets or clefts which had functioned, namely, had menstruated, and the secondary pelvic adenomas had arisen from them. From my studies, I am inclined to consider them possibly as either one or the other of these. It is also possible that their origin was independent of the ovaries.

A review of the reported cases of ectopic "adenomyoma" in the literature is of little value in determining their relation to ovarian hematomas as the writers were especially interested in the "adeno-

myoma" and probably paid very little attention to the condition of the ovaries unless they were strikingly abnormal. Sammelink and Joslin de Jong's case (reported by Lockyer and already referred to) in which the "adenomyoma" of the uterus had "invaded" the ovary would admit of a reverse interpretation and also a similar case (Case 6) reported by Cullen.[10] In Mahle and MacCarty's [13] case of "adenomyoma" of the sigmoid from the Mayo Clinic, "tarry" cysts of both ovaries were found. In the description of Cullen's [14] reported cases of "adenomyoma of the rectovaginal septum" an occasional reference is made to the fact that a "corpus luteum cyst" was found in one or both ovaries (four of his eighteen cases). Further studies alone will determine to what extent ovarian hematomas are responsible for the development of pelvic adenoma of endometrial type and by them we will also be able to

Fig. 32 (Case 13).—Photomicrograph of a "gland" of endometrial type in hemorrhagic tissue about the site of perforation *p* of the cyst shown in Figure 28. Such a gland as this might become detached during "menstruation" and, escaping into the culdesac, give rise to a secondary growth of endometrial type.

determine which lesions are caused by the epithelial tissue carried with the contents of the cysts and which ones by the irritating action of the contents aside from this epithelial tissue. There is such a great variation both in the invasiveness of the pelvic adenomas and also in their finer histologic appearance that one wonders whether they are all the same. These are all problems for further study.

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13. Mahle, A. E., and MacCarty, W. C.: Ectopic Adenomyoma of Uterine Type (A Report of Ten Cases), J. Lab. and Clin. Med. **5**:218-228 (Jan.) 1920.

14. Cullen, T. S.: Adenomyoma of the Rectovaginal Septum, J. A. M. A. **62**:835-839 (March 14) 1914; Adenomyoma of the Rectovaginal Septum, ibid. **67**:401-406 (Aug. 5) 1916; Bull. Johns Hopkins Hospital **28**:343-349 (Nov.) 1917, and Footnote 10.

CLINICAL FEATURES OF TWENTY-THREE CASES

As has been mentioned earlier in this paper, this condition is a disease which develops during the menstrual life of women, especially from 30 years of age until the menopause. Only two of the patients were under 30, the youngest being 26. None had passed the menopause. The oldest was 47 years old. Twelve of the patients were from 30 to 40 years of age and nine from 40 to 47 years, inclusive. The age incidence corresponds to that of myoma of the uterus.

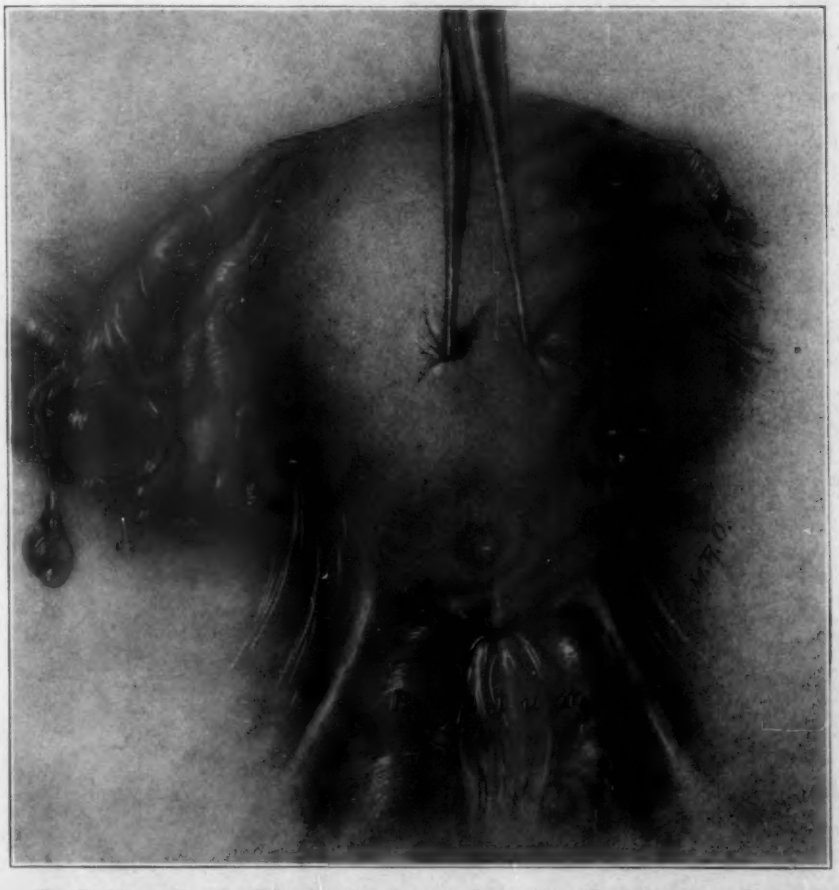

**Fig. 33 (Case 13).—Condition found at the second operation, March 21, 1921. On drawing the uterus upward, the anterior wall of the rectum is carried with it as it is fused with the posterior wall of the cervix (Fig. 34).**

Of the married women, fifteen in number, nine had never been pregnant. Of the six who had borne children, only three had had more than one. The shortest time that had elapsed since childbirth in any of these cases was five years. It would seem that this condition is likely to occur in women who were sterile; or if they had borne children, there was a subsequent history of sterility probably in part due to the age of the patient.

The most important factors in the origin of the subjective symptoms in these cases are the extent and situation of the adhesions and also other pelvic diseases which may be present. In some instances, other pelvic diseases are the more important conditions and in other cases the condition resulting from these cysts may predominate.

We are likely to find associated with these cysts any pelvic condition occurring in women from 30 years of age to the menopause. There are two possible exceptions in which a common age incidence does not

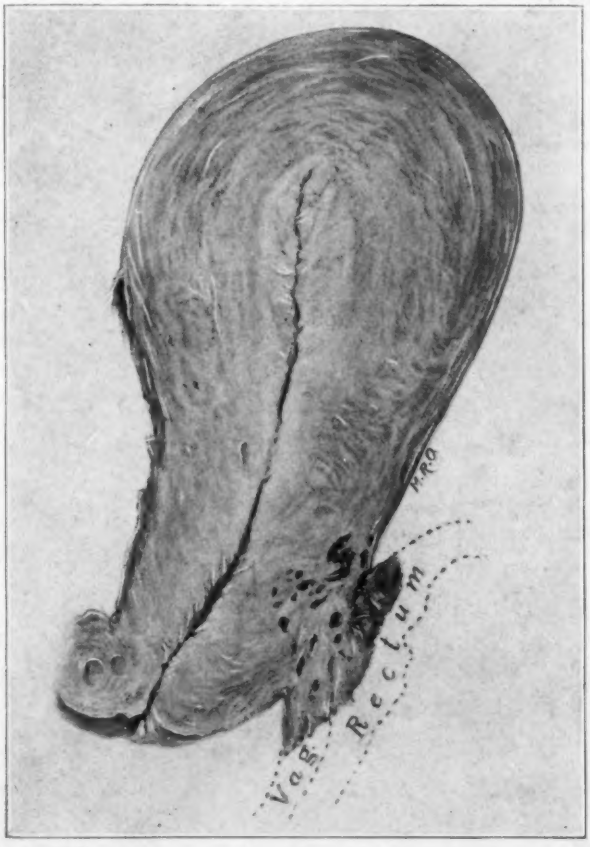


Fig. 34 (Case 13).—Adenoma of endometrial type involving the posterior wall of the cervix and the adjacent wall of the rectum. Sagittal section of the uterus removed at the second operation. The bottom of the culdesac has been obliterated by the adhesions resulting from or associated with the adenomatous growth and fusing the anterior rectal wall to the posterior wall of the cervix and the vagina. The adenomatous spaces have extended about half way through the cervix toward the cervical canal and have only slightly invaded the rectal wall and the vagina.

hold true; these cysts are more common in women who have not borne children, nine to six in the fifteen married women; they are apparently rare in women who have had salpingitis, a common condition in women over 30 years of age and also a common cause of sterility.

In not a single instance of the twenty-three cases reported in this paper was there any gross evidence of a recent or an old inflammatory disease of tubal origin; the fimbriated extremities of the tubes in all cases appeared normal and whatever adhesions were present about the tubes were of extratubal origin, that is, from the contents of the cyst.

The age incidence is that of uterine myomas which we would expect to find present in a large percentage of the cases; and this is true. Uterine myomas of varying size and numbers were found in ten of the twenty-three cases. In eight of these they were small and insignificant; in the other two they were larger (Cases 8 and 22) and gave rise to the tumor or condition for which the operation was undertaken. Even in these two cases the myomas were of secondary importance to the

Fig. 35 (Case 13).—Stained longitudinal section of the posterior wall of the cervix (× 5) shown in Figure 34. The growth has extended about half way through the cervical wall and has only slightly invaded the rectum and vagina. Many varieties of adenoma and adenocystoma of endometrial type are present, as, areas resembling normal endometrium, glandular hypertrophy, small cysts with low, cuboidal, or columnar epithelium with, and without, a stroma between the epithelium and the underlying cervical tissue. No connection between the cervical mucosa and the adenoma was found.

adhesions resulting from the hemorrhagic cyst. Cancer of the uterine cervix was found once, and the condition resulting from the hemorrhagic cysts in this case was of minor importance (Case 20). Retroflexion or retroversion of the uterus was found in eleven instances, and in ten of these, adhesions between the uterus and the rectum were found. The condition under consideration must be looked on as a cause of adherent retroverted or retroflexed uterus, especially when the adhesions are situated between the rectum and the uterus.

The hemorrhagic cysts were usually small, from 2 to 4 cm. in diameter, only four were larger than 4 cm., the largest being approximately 9 cm., so the size rarely contributes to the subjective symptoms.

Also whether they are unilateral or bilateral probably has little bearing on these symptoms except as bilateral cysts may contribute to sterility. They were bilateral in eight of the twenty-three cases.

The situation and extent of the adhesions may or may not contribute to the subjective symptoms as in patients with adhesions due to other conditions. The menstrual history varied greatly. Painful menstruation was a symptom in eleven cases, while on the other hand, twelve of the patients menstruated without any pain. When one considers the many factors causing or contributing to dysmenorrhea,

Fig. 36 (Case 13).—Photomicrograph of a portion of the posterior wall of the cervix showing the invasion of the adenoma into the cervical tissues from the peritoneal surface of the cervix, i. e., from "without."

it is often difficult to determine the part played by any pathologic condition found in a single case. I believe adhesions due to these hemorrhagic cysts may cause painful menstruation, especially as in Cases 2, 4, and 22 in which the dysmenorrhea was of recent development and had increased in severity. The amount of the menstrual flow varied greatly in the cases in this series. It was moderate or scanty in fifteen, profuse in six and intermenstrual bleeding occurred

in two. In the six with profuse menstruation, intramural myomas were found in three; in two of which they were small, in two of the others a retroflexed uterus and hemorrhagic cyst were the only pathologic conditions present. In the sixth case, there was an extensive adenoma of the posterior uterine wall apparently not connected with the uterine mucosa. Of the two with intermenstrual bleeding, one had a cancer of the uterine cervix, in the other the pathologic conditions

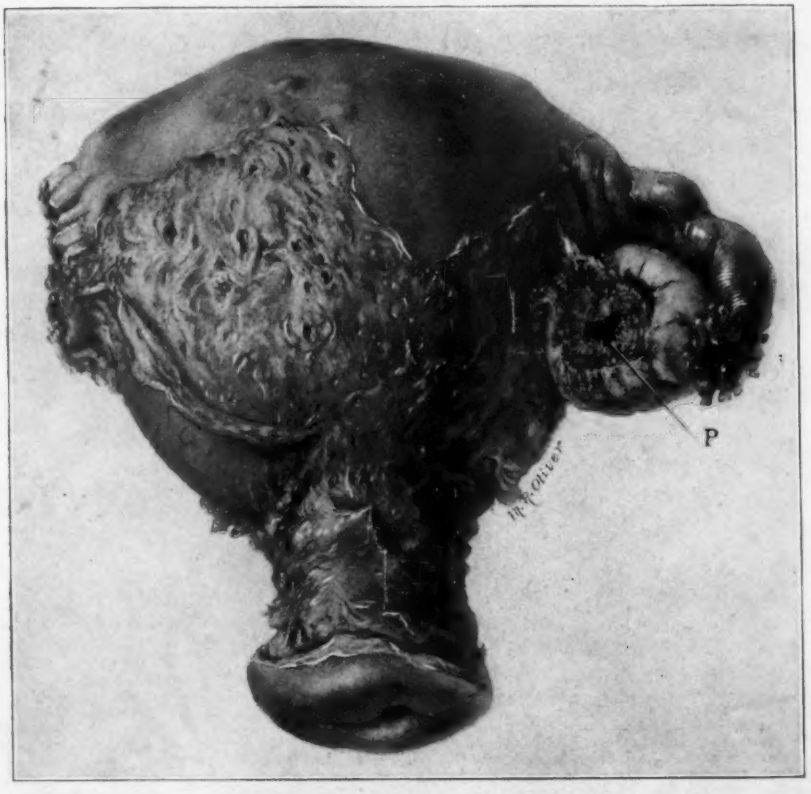


Fig. 37 (Case 15).—Perforating hemorrhagic cyst of the right ovary with diffuse superficial adenoma of endometrial type of the posterior uterine wall which had fused with the anterior wall of the rectum and the bottom of the culdesac. Posterior view of the uterus, right tube and ovary (natural size). The ovary had been freed at operation from the posterior surface of the uterus to which it was adherent. It is shown partially collapsed with a raw area and perforation in the center of it. The greater portion of the posterior wall of the uterus, represented by the large raw area, was adherent to the rectum and bottom of the culdesac. The small dark depressions and areas represent adenomatous tissue (blebs) (Fig. 41) which had been exposed or torn in freeing the uterus from the rectum and bottom of the culdesac and the ovary. The small elevations on the surface of the fundus above the large raw area represent superficial subperitoneal adenomatous blebs which had not been ruptured.

found were an adherent retroflexed uterus, bilateral ovarian hemorrhagic cysts and a small intramural myoma. It is very difficult to decide whether or not these cysts cause profuse or irregular (too frequent) menstruation.

Eight of the twenty-three patients did not have pain as a leading symptom. In three of these the adhesions were very extensive. Fifteen, however, did have pain. In three of these, the pain was probably due to trouble with the appendix. In the other twelve cases, the adhesions resulting from the ovarian cysts or cyst were the apparent cause of the pain. The pain varied in severity and location as does pain due to adhesions from any other cause. There is usually nothing characteristic about the pain present in this condition nor is there necessarily any relation between the extent of the adhesions and the severity of the pain. Only one patient gave a history of an acute onset with symptoms of peritonitis (Case 2). In all the others the onset was gradual. Four of the patients suffered greatly from constipation which amounted to partial obstruction in one instance (Case 19).

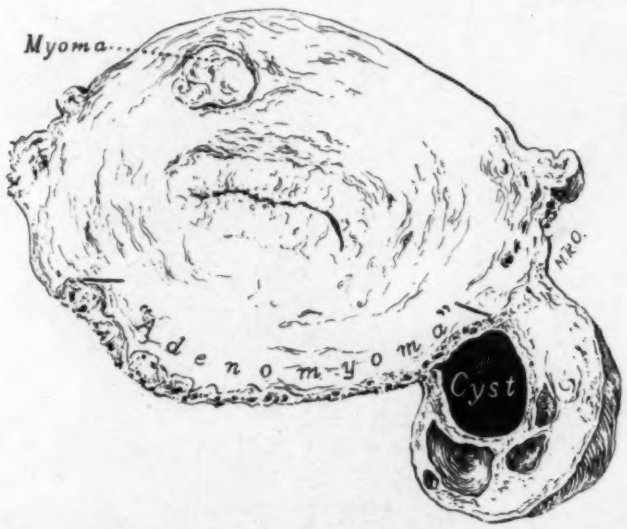


Fig. 38 (Case 15).—Cross section of the uterus with right ovary attached to the posterior uterine wall. The perforation in the ovary had been sealed by its attachment to the posterior wall of the uterus. The adenoma apparently beginning in the right ovarian cyst had extended across the entire posterior surface of the uterus at this level. There is a reaction of the uterine tissue about the glandular areas forming an "adenomyoma." Sections made through the entire uterine wall showed that the adenoma had invaded it only for the distance indicated in the illustration, and that none was found between this area and the uterine cavity.

Of the twenty-three patients, six presented symptoms due to other conditions and the hemorrhagic cysts were accidental findings. In seventeen of the twenty-three cases, the prominent symptom or symptoms were probably due to the cysts themselves or adhesions resulting from them. In twelve of the seventeen, pain was the one symptom from which the patient sought relief, in three increasing constipation, in one uterine bleeding and in one sterility.

### SUMMARY OF CLINICAL FEATURES

The age at which such cysts with their sequelae occurs is usually between 30 years and the menopause.

There is often a history of sterility or of no children in several years. Sometimes there are not any subjective symptoms referable to this condition. If painful menstruation results, it is of the acquired variety, of recent development and may be progressive in severity.

If pain is present, it is not characteristic but varies in character as does pain associated with pelvic adhesions due to other conditions.

Sometimes constipation, worse at the menstrual period, is a suggestive symptom (Case 19). The symptoms of the advanced cases with narrowing of the lumen of the intestine are similar to those of intestinal obstruction due to other causes such as malignancy.

The physical signs vary greatly. If the cysts are small and adherent to the posterior surface of the uterus it may be difficult or impossible to detect them. If they are adherent to the posterior layer of the broad ligament or the side of the pelvis they are more readily palpated and

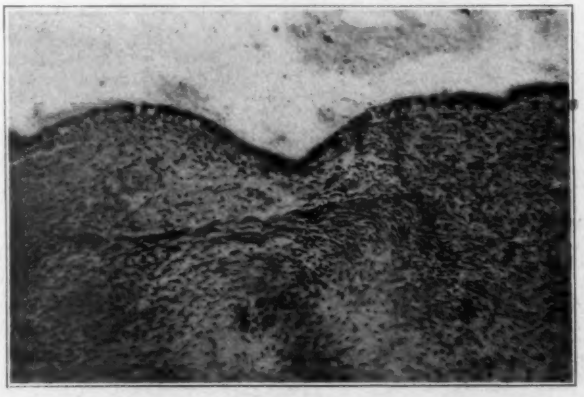

Fig. 39 (Case 15).—Photomicrograph of the wall of the hemorrhagic cyst shown in Figure 38. The entire cyst cavity is lined by a single layer of cuboidal or columnar cells with an underlying vascular stroma.

simulate adherent cystic ovaries or hydrosalpinx due to pelvic peritonitis of tubal origin. If the cysts are of medium size or larger and their adhesions are extensive the condition may simulate a malignant ovarian cyst (Case 9). The palpatory findings in the culdesac, when present, are the most characteristic physical signs. The uterus is often retroflexed or retroverted and adherent and the degree of adenomatous growth in the culdesac varies greatly in character in different cases. When slight, it is impossible to detect it. The involvement may be localized or diffuse. If localized, the area of induration may be flat or nodular, in the median line just behind the cervix or laterally in the region of the uterosacral ligaments. The induration is usually low down, but occasionally may be higher up. Sometimes it is best

detected on vaginal palpation and at other times felt best through the rectum. The diffuse and extensive involvement of the culdesac simulates the implantation of ovarian cancer or papilloma in this situation. The implantation from the latter source, however, is usually more extensive and much thicker.

The extensive involvement of the rectogenital space by "adenomyoma" is well described by Lockyer [8] in his excellent work on fibroids and allied tumors and by Cullen [10] in his published cases of "adenomyoma of the rectovaginal septum."

From this it can be seen that it is possible to make a tentative and often a probable diagnosis in a large percentage of the cases prior to operation. As we may diagnose a papillomatous or malignant ovarian cyst by palpating a cystic pelvic tumor which is usually

Fig. 40 (Case 15).—Photomicrograph of a cleft in the ovary near the site of perforation of the cyst. The cleft is lined by tissue of endometrial type resembling the normal endometrium more closely than that lining the cyst.

adherent and in addition find "involvement" of the culdesac due to the implantation of the growth in that situation, in like manner we are often able to diagnose this type of ovarian cyst with its secondary involvement of the culdesac. It differs from the malignant growth in that the ovarian tumor is usually much smaller, the culdesac involvement usually less and more localized, appearing as a nodule of localized thickening. The general clinical picture also is not that of malignancy.

### TREATMENT

The operative treatment of any pelvic condition must be determined by many factors, such as the pathologic condition present, the age of

the patient, her desire for conservative surgery, the results of the operative treatment of similar conditions and especially the natural course of the disease when no operation was performed. There are obviously two pathologic conditions to treat, the one present in the ovary or ovaries, and the secondary adhesions in the pelvis which are often associated with an adenoma of endometrial type, the latter varying greatly in the degree to which it has invaded the tissues and organs involved.

One would suppose that with the establishment of the menopause ovarian function would cease and that then the tissues of endometrial type, wherever situated, would not only cease to grow but would actually atrophy. I believe this is the rule; undoubtedly, there may be

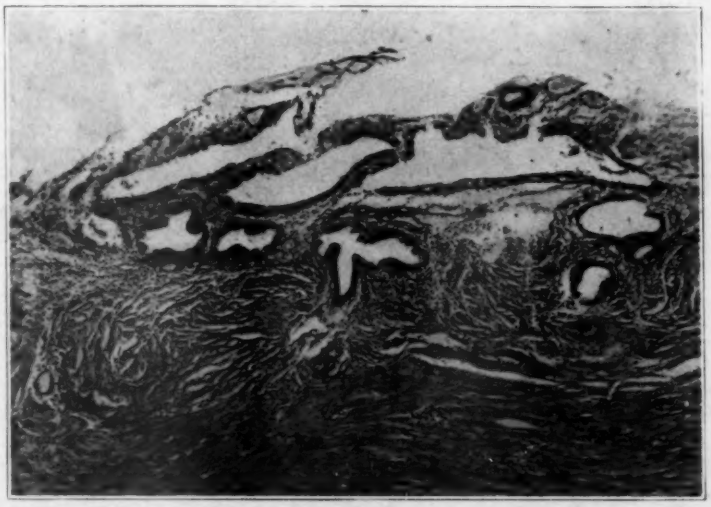

Fig. 41 (Case 15).—Photomicrograph of a section of the posterior uterine wall showing adenoma of endometrial type on its surface similar to that shown in Figure 24 (Case 21). As indicated, it is beginning to invade the uterine wall. The process in the ovarian hematoma, in the clefts of the ovary about the site of perforation, and the posterior surface of the uterus are the same, namely, an invasive adenoma of endometrial type. Apparently, the uterine involvement is secondary to the ovary by direct extension or implantation from the epithelial contents of the cyst.

an occasional exception. I have never found one of these cysts or a pelvic adenoma of endometrial type in a woman after the menopause.

To remove the pelvic adenoma and disregard the ovarian condition would be to leave the original growth behind, and furthermore, the persistence of the ovarian function might increase the growth of secondary pelvic adenomas not removed. *Certainly we would not sanction the surgical judgment of the operator who removed the secondary peritoneal implantations of ovarian papilloma or cancer and did not remove the primary ovarian tumor.* The conditions are analogous except that fortunately the adenoma of endometrial type

is only rarely sufficiently invasive to cause serious damage to the parts involved. By referring to the report of the cases in this article, one may see that various operations have been performed.

In some of the conservative operations, only the diseased portions of one or both ovaries have been removed (Cases 14 and 16). In others, one tube and ovary have been removed without excising the pelvic tissue in which adenoma was probably present (Cases 9, 10, 11 and 13). In still others, the entire uterus was removed, leaving behind one tube or ovary or a portion of an ovary and pelvic tissue was removed at the same time, which showed adenoma of endometrial type (Cases 15, 18 and 21). In the last group of cases, adenomatous tissue was undoubtedly left in the pelvis.

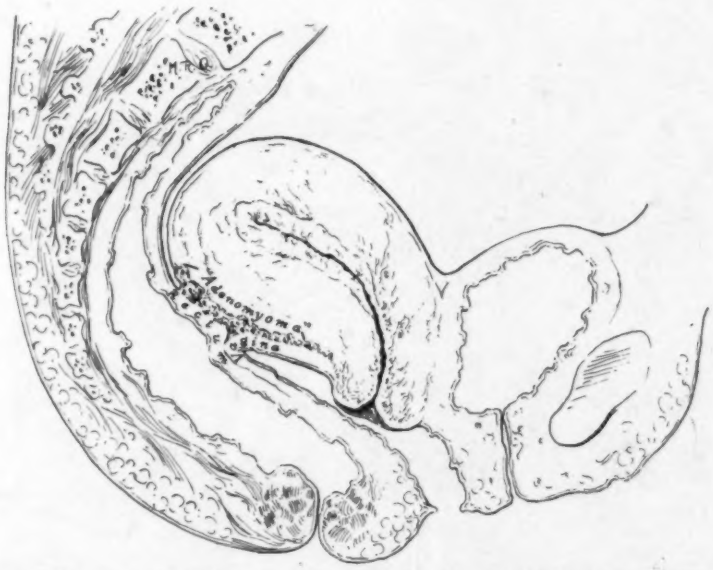


Fig. 42 (Case 15).—Sagittal section of the pelvis showing the relation of the "adenomyoma" to the uterus, rectum and vagina prior to the operation. The adenoma involves the superficial portion of the posterior uterine wall and has united it to the anterior wall of the rectum and posterior wall of the vagina. The upper part of the vagina has been pulled away from the rectum by the retroflexion. One can see how the adenoma would easily grow down between the rectum and vagina, invade the vaginal wall, and present in the vaginal vault behind the cervix, as in Figure 52 (Case 23).

In one of these conservative cases, a second operation has been necessary (Case 13); and in this instance, the adenoma in the culdesac had increased in size in less than a year's time and necessitated a radical operation. I believe that some of the other cases, in which I have employed conservative surgery, may later require secondary radical operations as Cases 10 and 11. Casler's [9] case already referred to is an extreme example of the possible result of conservative surgery in these cases. Only the end-result in a large number of cases of

conservative ovarian surgery will show whether or not it is justifiable. Even if it proves to be justifiable, I am sure that an occasional patient will require a secondary radical operation. It is possible that the rupture of the cyst at operation may "infect" the pelvic tissues with the epithelial contents of the cyst and that the retained ovary or ovaries may stimulate it to further growth.

I have never resorted to the extremely radical operations, as in cancer of the uterine cervix, and even in these operations it may be

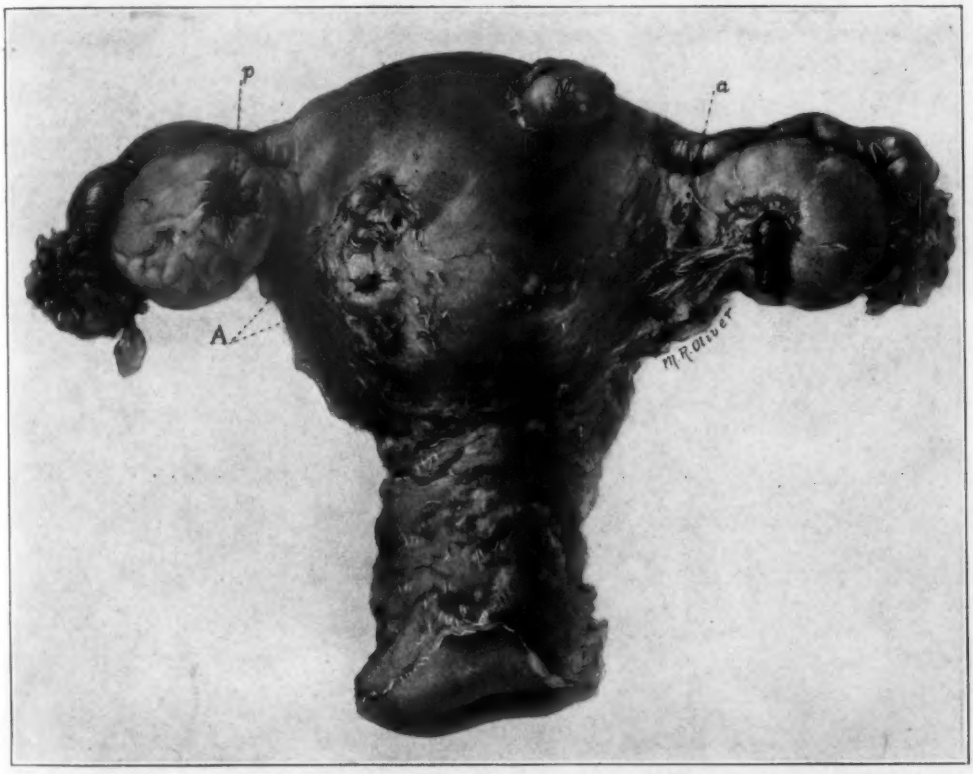


Fig. 43 (Case 17).—Perforating hemorrhagic cysts of both ovaries with discrete "adenomyomas" of the posterior wall of the uterus. Posterior view of the uterus, tubes and ovaries (natural size). At operation both ovaries were adherent to the posterior surface of the uterus. The left ovary is partially collapsed, due to the escape of the contents of the cyst; the raw area with perforation in the center is shown. The contents of the hematoma of the right ovary was thicker than that of the left and is indicated as oozing from the perforation. At and about the surface of the uterine wall which was adherent to the left ovary can be seen slight elevations (*A*) which proved to be superficial "adenomyomas" (Fig. 46). Adenoma of endometrial type was found developing between the adherent right ovarian ligament and the surface of the uterine wall at *a*, Figure 45. Sections were taken from other portions of the uterine wall and adenoma was not found.

impossible to remove all of the adenomatous growth. In the radical operations which I have employed, I have removed the entire uterus with both ovaries, and in freeing the uterus from the rectum, I have purposely kept close to the uterus, undoubtedly sometimes leaving adenoma in the rectal wall. In freeing the cervix laterally, I have

kept close to it, in one case intentionally leaving adenoma in the broad ligament because it was too extensive to remove (Case 12). Only the end-results of a large number of cases will show whether or not this type of radical operation is the one of choice. Undoubtedly, in any type of operation, no matter how radical, adenomas may sometimes be left in the pelvis, but with the removal of all ovarian tissue, I believe it will usually cease to grow and may atrophy (Cases 2, 3, 6 and 12).

In one instance (Case 19), I removed the entire uterus, both tubes and ovaries, a portion of the sigmoid; and in this case, adenoma was undoubtedly left in the anterior wall of the rectum and a distinct nodule in a portion of the sigmoid was not removed. I am anxiously awaiting the end-result in this case. So far she has been completely relieved and feels perfectly well.

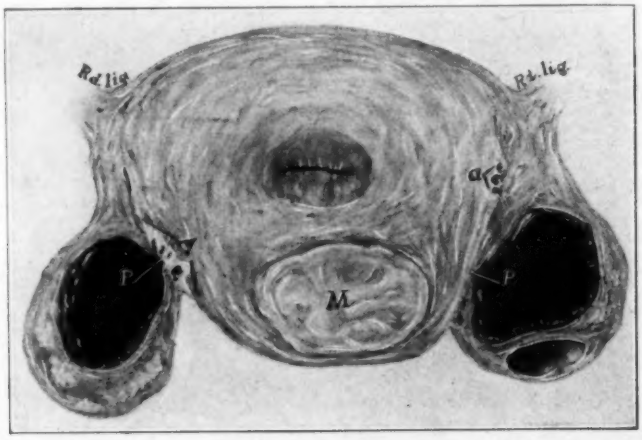


Fig. 44 (Case 17).—Cross section of the uterus and ovaries showing their relation prior to the operation (natural size). The ovaries are adherent to the posterior surface of the uterus at the site of perforation. The deeper portions of the ovarian cysts were lined by a wavy pigmented layer without an epithelial covering, while the proximal portions (toward the perforations) were lined by low, cuboidal and columnar epithelium, i. e., possibly a secondary "epithelialization" from the surface or periphery of the ovary about the site of perforation or regeneration of the epithelial lining of the cyst after hemorrhage, as in Figure 17. Adenomas of endometrial type were also present in the periphery of the ovary. Discrete superficial adenomyomas (*A*) are situated in the posterior uterine wall beneath the adherent left ovary at the site of perforation (Fig. 46), and adenoma of endometrial type is found developing between the right ovarian ligament and the uterine wall at *a* and invading the latter (Fig. 45).

There seems to be a great variation in the degree of "invasiveness" of the secondary pelvic deposits which is often evident in the individual case at operation. My present plan is to employ ovarian conservatism (excising the portion of the ovary or ovaries involved) or removing only the apparently diseased ovary in patients who desire to have the ovarian function maintained but only if the invasion of the pelvic tissues by the adenoma is slight. I am anxiously waiting to see

whether the end-results will justify this stand. I am inclined to believe that ovarian conservatism is a rather dangerous experiment. In all other cases, either when ovarian conservation is not strongly desired or when the pelvic growth is apparently actually invasive, I believe that all ovarian tissues should be removed and as much as possible of the pelvic growth with it. We must not lose sight of one fact, and that is that for many years we have been operating on these patients without realizing the exact nature of the disease. On the whole, the results have usually been quite satisfactory because the growth is usually only mildly invasive. With a better knowledge of this subject and by following up our cases, we should soon be able to determine the proper treatment of this condition

## REPORT OF CASES

CASE 1.—*Perforating hemorrhagic cysts of both ovaries; multiple leiomyomas of the uterus; dense adhesions in the culdesac uniting the anterior rectal wall to the supravaginal portion of the cervix and the lower portion of the uterus. The induration of the anterior rectal wall was so great as to simulate malignancy.*—Mrs. M. G., aged 46, complained of an abdominal tumor, of six

Fig. 45 (Case 17).—Photomicrograph of adenoma of endometrial type developing between the adherent right ovary and the uterus (Figs. 43 and 44). The adenoma can be seen sinking into the uterine wall.

months' duration, and constipation. She had never been pregnant; menstruation had been more profuse lately but regular and without pain. Pelvic examination revealed an adherent irregular "uterine" tumor, extending half way to the umbilicus. The preoperative diagnosis was a multinodular myomatous uterus, associated with pelvic adhesions, probably of tubal origin.

Operation at the Albany Hospital, March 5, 1910, demonstrated a multinodular myomatous uterus with adherent bilateral hemorrhagic ovarian cysts. Further details of this case have already been described in the text of the article in the section on incidence. The ovarian cysts and posterior wall of the uterus were not examined microscopically.

CASE 2.—*Perforating hemorrhagic cysts of both ovaries; "adenomyoma" of the posterior wall of the uterus, adherent to and invading the anterior wall of the rectum.*—Miss B. K., aged 37, complained of profuse menstruation and indefinite pains in the lower abdomen. The menstruation was regular, profuse,

more so lately, and accompanied with severe pain. Pelvic examination revealed the uterus to be slightly enlarged and apparently adherent, with "inflammatory masses" on each side. Preoperative diagnosis was a myomatous uterus (probably an intramural myoma) with chronic "inflammatory disease" of the tubes and ovaries.

At operation at the Albany Hospital, March 27, 1912, an enlarged uterus was found adherent to the rectum with adherent moderate sized ovarian cysts. On freeing the latter, "chocolate" fluid escaped. The uterus was freed from the rectum with great difficulty. The appendix, both tubes, ovaries and uterus were removed. The tubes appeared normal, both ovaries had been converted into cysts approximatey 4 and 6 cm. in diameter. They were not examined microscopically. The posterior portion of the posterior wall of the uterus was occupied by an "adenomyoma" which apparently was not continuous with the mucosa of the uterine cavity. The "adenomyoma" had "extended through" the uterine wall posteriorly and apparently had actually invaded the anterior wall of the rectum (Fig. 64). In freeing the uterus from the rectum, some of the growth was probably left attached to, or in, the rectal wall. The patient made a satisfactory convalescence and has remained well even though it is doubtful whether all the adenomatous tissue was removed at operation.

Fig. 46 (Case 17).—Enlargement (× 5) of "adenomyoma" situated in the posterior wall of the uterus beneath the adherent left ovary (Figs. 43 and 44). Several sections were made of the posterior uterine wall and adenoma of endometrial type was found only in the portions of the uterine wall to which the ovaries were adherent, suggesting an intimate relation between the adenoma of endometrial type of the ovary and that developing in the uterine wall.

CASE 3.—*Perforating hemorrhagic cysts of both ovaries; adherent retroflexed uterus; adenoma of endometrial type invading the posterior wall of the uterus and uniting it with the anterior wall of the rectum.*—Mrs. C. A. D., aged 37, complained of pain of one year's duration in the left side of the lower part of the abdomen. She had been in bed ten days at the onset of the pain. The diagnosis of "peritonitis" was made at that time. She had been married eleven years, had two children, 10 and 8 years of age, and no miscarriages. The menstruation was regular, moderate and normal, the last flow being a week before the operation. Pelvic examination revealed the uterus to be retroflexed, adherent, with probable cystic inflammatory masses on each side. Preoperative diagnosis was an adherent retroflexed uterus with bilateral hydrosalpinx or adherent cystic ovaries.

At operation at the Albany Hospital, April 26, 1912, an adherent retroflexed uterus was found with adherent cystic ovaries. On freeing the latter, "chocolate"

fluid escaped. The uterus was freed from the rectum with difficulty. The appendix, both tubes and ovaries and the uterus were removed. The tubes appeared normal; each ovary contained a hematoma, the one in the left ovary being the larger (about 3 cm. in diameter). Histologically, the epithelial lining of the cysts was for the most part lacking. When present, it was low, cuboidal, resting on ovarian tissue without any intervening stroma. In a few places in the cyst wall, definite glandlike structures, lined by columnar cells similar to uterine glands, were found. The lower portion of the posterior wall of the uterus and the supravaginal portion of the cervix were invaded by an adenomatous growth of endometrial type. The depth of the invasion was not more than 4 or 5 mm. (Fig. 63). In places, there was a reaction of the tissues of the uterine wall forming a definite nodule, i. e., an "adenomyoma." The patient made a satisfactory convalescence and has remained well.

Fig. 47 (Case 23).—Perforating hemorrhagic cyst of the left ovary; adherent retroverted uterus; adenoma of endometrial type of the culdesac invading the posterior wall of the cervix and extending through the vagina and presenting as a hemorrhagic cyst in the vaginal vault. View of pelvic contents from sketch made at the operation (slightly reduced in size). The uterus was retroverted, the ovary drawn up over the left tube and adherent to the round ligament. The tip of the omentum was also adherent to the ovary and the round ligament at this point. The right tube and ovary were apparently normal. On freeing the omentum, "chocolate" fluid escaped from the perforated ovarian cyst, the perforation having been sealed by the omentum and round ligament.

CASE 4.—*Perforating hemorrhagic cyst of the left ovary; multinodular myomatous uterus; submucous "adenomyoma" of the right uterine cornu; dense adhesions in the culdesac uniting the posterior wall of the uterus to the rectum.*—Miss E. D. W., aged 40, complained of severe dysmenorrhea of four months' duration, especially in the left side, and some pain in the same side for a week after the menses had ceased. The menstruation was regular, moderate, free from pain until the last four months; since then there has been severe pain as noted above. Pelvic examination demonstrated the uterus to be irregularly enlarged and apparently adherent. Preoperative diagnosis was an adherent myomatous uterus.

Operation at the Albany Hospital, Oct. 11, 1917, revealed the uterus to be irregularly enlarged with an adherent ovarian cyst, approximately 6 cm. in diameter on the left side. On freeing the latter, "chocolate" fluid escaped. The uterus was adherent to the rectum. The appendix, both tubes, ovaries and the entire uterus were removed. The tubes appeared normal, the right ovary was cystic, the left was converted into a hemorrhagic cyst. There were multiple leiomyomas in the uterus and an "adenomyoma" in the right uterine cornu (Fig. 15). Sections of the left ovary were not satisfactory and none were made of the posterior uterine wall to determine whether or not adenomyoma of endometrial type was present. The patient made a satisfactory convalescence and has remained well.

CASE 5.—*Perforating hemorrhagic cyst of the right ovary; adherent retroflexed uterus; tip of the appendix adherent to the cyst.*—Miss G. D., aged 28, complained of two "attacks of appendicitis," the first one three months ago and the last one a month ago. She was in bed about a week with each

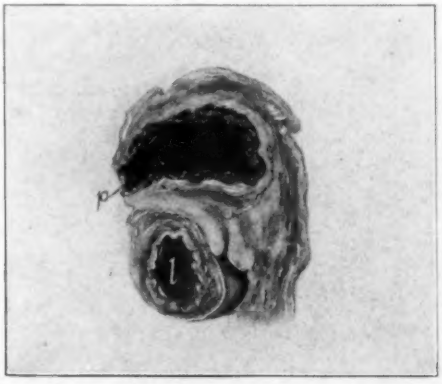


Fig. 48 (Case 23).—Cross section of the ovary shown in Figure 47 (natural size). The ovarian hematoma is for the most part lined by a single layer of columnar cells with a vascular underlying stroma (Fig. 49). In places where the epithelium is absent, a thick layer filled with pigmented cells is present, evidence of a previous stromal hemorrhage. A corpus luteum (*L*) is situated near the ovarian hematoma as in Figure 16 (Case 21).

attack. The menstruation was apt to be two or three days late and slight in amount; there was slight pain and the last flow was a week before the operation. Pelvic examination showed the uterus to be retroflexed and adherent, with an adherent cystic mass in the right side of the pelvis. The preoperative diagnosis was adherent retroflexed uterus with adherent ovarian cyst.

Operation at the Albany Hospital, Feb. 7, 1918, revealed an adherent retroflexed uterus, with an adherent ovarian cyst on the right side. The appendix dipped into the pelvis and was adherent by its tip (Fig. 11). On freeing the cyst, "chocolate fluid" escaped. The appendix, right tube and ovary were removed and the uterus was suspended. Only one section from the ovarian cyst was made for microscopic diagnosis; this showed a cyst with its wall lined by low and cuboidal epithelium. No sections were taken from the posterior wall of the uterus to see whether or not adenoma of endometrial type was present.

CASE 6.—*Perforating hemorrhagic cyst of the right ovary; adherent retroflexed uterus; "adenomyoma" of posterior uterine wall; gallstones.*—Mrs. J. A. J., aged 45, complained of indigestion and attacks of pain in the upper right abdomen. She had been jaundiced four weeks before. There were no definite symptoms referable to the pelvic condition. She was not constipated. She had had one child—13 years old. The menstruation was regular but scanty; there was no pain; the last flow was a week before the operation. The pelvic examination showed the uterus to be enlarged, retroflexed and adherent. The preoperative diagnosis was gallstones and an adherent myomatous uterus.

Operation was performed at the Albany Hospital June 13, 1918. A median incision was made and the gallbladder palpated and gallstones felt. The appendix was then removed. The uterus was enlarged, retroflexed, and densely adherent to the rectum. On freeing the right ovary "chocolate" fluid escaped. Both tubes and ovaries and the entire uterus were removed. An incision was then made over the gallbladder, and it was removed. Both tubes were normal,

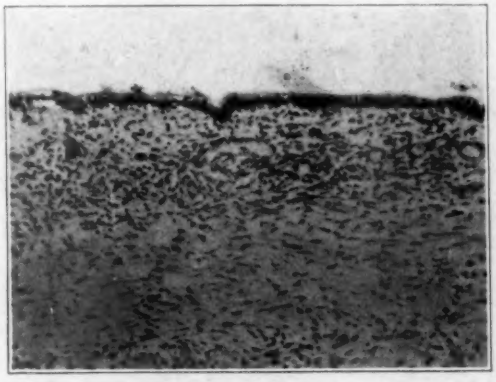

Fig. 49 (Case 23).—Photomicrograph of the wall of the cyst from the portion lined by columnar epithelium with an underlying vascular stroma similar to Figure 19 (Case 21), and Figure 39 (Case 15).

the left ovary was normal, the right ovary contained a hemorrhagic cyst about 2.5 cm. in diameter. There was a superficial "adenomyoma" of the posterior wall of the uterus which had "united" it to the anterior wall of the rectum. The exact depth of the invasion or the involvement of the uterus wall was not determined. The hemorrhagic cyst was lined by low, cuboidal and columnar epithelium, the columnar predominating. There was a vascular subepithelial stroma, containing evidence of old and recent hemorrhages and an occasional gland, which resembled a uterine gland. The patient made a satisfactory convalescence and has remained well.

CASE 7.—*Perforating hemorrhagic cysts of both ovaries; multiple ovarian hematomas; small leiomyomas of the uterus, adhesions between the posterior uterine wall and the ovaries.*—Mrs. X. W., aged 35, complained of uterine bleeding which had occurred six times in the last twelve weeks. She had never been pregnant; the menstruation was regular, moderate and normal until the last three months. Since then it had been more profuse and frequent and had been accompanied with pain. Pelvic examination showed the uterus to be

slightly enlarged, and apparently irregular in consistency, with inflammatory masses on either side. Preoperative diagnosis was a myomatous uterus with bilateral "chronic pelvic peritonitis."

Operation at the Albany Hospital, Nov. 10, 1918, revealed both ovaries to be cystic and adherent to the posterior surface of the uterus. Small myomas were present in the uterus. On freeing the ovaries, "chocolate" fluid escaped. The appendix, both tubes and ovaries and the entire uterus were removed. The tubes appeared normal, both ovaries contained multiple hematomas from 1 to 1.5 to 4 cm. in diameter. Histologically, the hematomas represented various stages in the life cycle of "luteal" hematomas. In one cyst, an adenoma of endometrial type was found. Sections were made from the portion of the posterior uterine wall which was adherent to the ovaries and adenoma of endometrial type was not found. The patient made a satisfactory convalescence and has remained well.

CASE 8.—*Perforating hemorrhagic cyst of the left ovary; multiple leiomyomas of the uterus; dense adhesions between the posterior uterine wall and the rectum.*—Mrs. S. K., aged 46, complained of pain in the left side of the lower abdomen for ten years. She had never had any children but possibly had a miscarriage eighteen years ago. The menstruation was regular, without pain; but it had been very profuse for the last year, lasting from five to seven days. The last menstrual flow was two weeks before the operation. Pelvic examination showed the uterus to be irregularly enlarged and apparently fixed in the pelvis. Preoperative diagnosis was a myomatous uterus with pelvic adhesions.

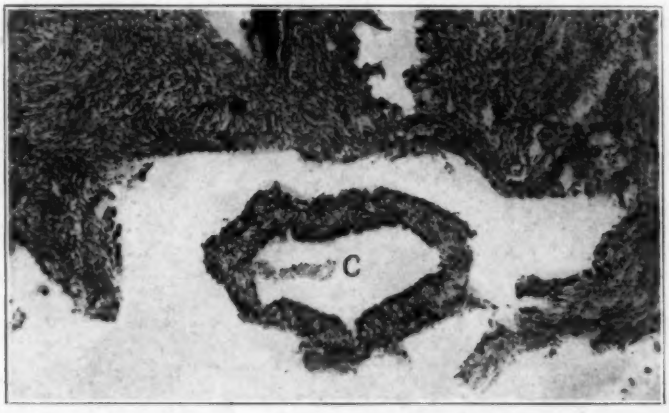


Fig. 50 (Case 23).—Photomicrograph of a small "cyst" partially detached from a pocket in the periphery of the ovary near the site of perforation (lower power than the preceding illustration). This cyst is lined by columnar cells surrounded by a cellular stroma and resembles the "cyst" on the surface of the round ligament (Fig. 70, Case 22). Both are apparently cysts of "endometrial" type.

Operation at the Albany Hospital, Jan. 16, 1919, revealed a multinodular myomatous uterus, pushed forward by a densely adherent left sided ovarian cyst about 8 cm. in diameter (Fig. 14). The right tube and ovary were normal. On freeing the ovarian cyst, a large amount of "chocolate" fluid escaped. The adhesions between the uterus and the rectum were very dense, and the two were separated with great difficulty. The appendix, both tubes, ovaries and

uterus were removed. Only one section was made from the cyst and that was unsatisfactory. Sections were not made from the posterior portion of the uterine wall to determine whether or not adenoma of endometrial type was present.

CASE 9.—*Perforating hemorrhagic cyst of both ovaries; dense adhesions in the culdesac uniting the anterior rectal wall to the supravaginal portion of the cervix and the lower portion of the uterus: postoperative hernia following the incision and drainage of appendiceal abscess twelve years previously.* —Mrs. C. J. H., aged 26, complained of pain in the right side. She had been married one and a half years and had not been pregnant. Menstruation was regular, normal, moderate in amount and not painful. The pain in the right side was of nine months' duration; at times it was severe enough to cause the patient to go to bed; she was not constipated. The pelvic examination showed the uterus to be of normal size and pushed forward by a "cystic" tumor extending nearly to the level of the umbilicus. The cyst appeared to be adherent. The preoperative diagnosis was an adherent ovarian cyst, probably a dermoid. On account of the adhesions, malignancy was also considered.

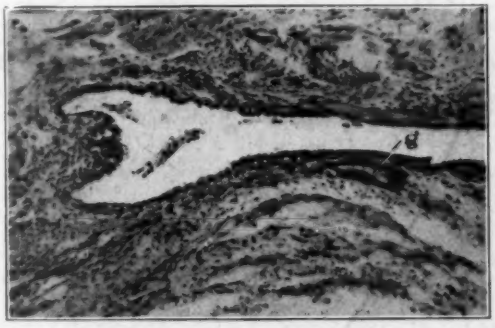

Fig. 51 (Case 23).—Photomicrograph of a peritoneal fold near the perforation of the cyst. This is an adenoma of endometrial type.

Operation at the Albany Hospital, March 17, 1920, revealed a left ovarian cyst about 9 cm. in diameter, posterior to the uterus and adherent to the posterior surface of the uterus and the anterior wall of the rectum (Figs. 12 and 13). On freeing it, a large amount of "chocolate" fluid escaped. A similar, but smaller, cyst was found in the right ovary. The appendix was removed; the hernia repaired; the left tube and ovary removed; the cyst excised from the right ovary and the uterus freed from the rectum and suspended. The tubes appeared normal. Histologically, the cysts were for the most part lined by epithelium of low to cuboidal type. Evidence of old and recent hemorrhages was found in the cyst wall. Tissue was not removed from the posterior wall of the uterus and the anterior wall of the rectum to determine whether or not adenomyoma of endometrial type was present. The patient made a satisfactory recovery and has remained well.

CASE 10.—*Perforating hemorrhagic cyst of the left ovary, adherent retroflexed uterus; acute appendicitis.*—Miss M. D., aged 34, was admitted to the Albany Hospital, May 8, 1920, with symptoms of acute appendicitis. Menstruation was regular, always profuse and accompanied by severe pain, especially in recent years; she often remained in bed for the first two days of the menstrual period. The last flow was two weeks before the operation. She

had had three "attacks of appendicitis" the first one in September, 1919, the second in December, 1919, and the third and present attack began the day before her admission to the hospital. The physical examination revealed tenderness and rigidity over the appendix; the uterus was retroflexed and adherent; the appendages on the left side were enlarged and adherent. The preoperative diagnosis was acute appendicitis, adherent retroflexed uterus, with adherent cystic ovary or hydrosalpinx on the left side.

Operation was performed on the day of admission. Through a median incision, the left ovary was found enlarged and adherent. On freeing the ovary, "chocolate" fluid escaped. The uterus was freed from the rectum, to which it was adherent, and suspended (Fig. 7). The appendix was also removed. Histologically the hemorrhagic cyst was lined by a single layer of low cuboidal or columnar epithelium, cuboidal predominating; there was in

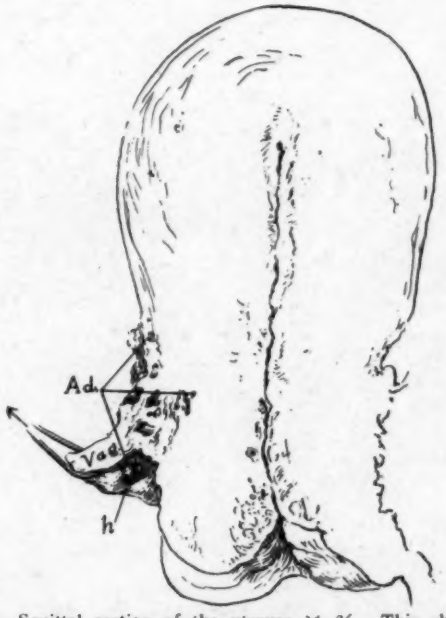


Fig. 52 (Case 23).—Sagittal section of the uterus; × 3/5. This shows the adenoma of endometrial type involving the posterior surface of the supravaginal portion of the cervix, invading the cervix and posterior vaginal wall at the cervicovaginal attachment and presenting in the posterior vault of the vagina as a small hemorrhagic cyst (*h*).

places a thin intervening vascular stroma between the epithelial lining and the ovarian tissue proper. Glandlike spaces lined by a single layer of columnar cells were found scattered through the cyst wall and were most numerous near the site of perforation (Fig. 9). A small "pocket" or cyst was situated lateral to the main cyst (Fig. 8). This pocket was lined by columnar epithelium accompanied by a definite underlying stroma, and in one place, there was a definite "endometrial" formation (Fig. 10). Evidence of old and recent hemorrhages were found in the cyst. Histologically, both cysts suggested that they were adenocystoma of the endometrial type. Tissues were not removed from the raw areas caused by freeing the adhesions to determine whether or not adenoma of endometrial type was situated in this area. The patient made a satisfactory surgical convalescence, but the dysmenorrhea has not been relieved

by the operation. I examined the patient in September, 1920, and could detect a definite small area of induration in the culdesac posterior to the cervix, which I believe is due to an adenoma of endometrial type in that situation.

CASE 11.—*Perforating hemorrhagic cyst of the right ovary, adherent to the side of the pelvis.*—Mrs. L. H., aged 30, complained of pain in the right side of the lower abdomen, especially during the menstrual period. The symptoms were of five months' duration. She had been married four years and had never been pregnant. Menstruation was regular, moderate in amount; she always had had some pain but this had been much worse for the last five months. The last flow was just passed. Pelvic examination showed the uterus to be normal in size and drawn slightly to the right side; the appendages on that side were apparently adherent. The preoperative diagnosis was "chronic pelvic inflammatory disease" probably of tubal origin.

Operation at the Albany Hospital, May 10, 1920, revealed the right ovary cystic and adherent to the side of the pelvis (Fig. 1). On freeing it, "chocolate" fluid escaped. The right tube, ovary and the appendix were removed. Histologically, the cyst for the most part lacked an epithelial lining, but when present, it consisted of a single layer of cells low to cuboidal in form (Fig. 3).

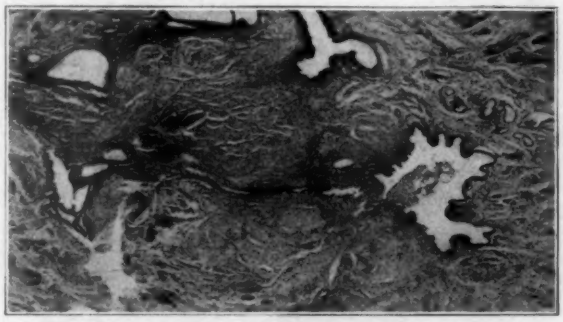

Fig. 53 (Case 23).—Photomicrograph of a portion of the cervix showing the "adenomyoma" with partially collapsed cavities which were filled with "menstrual" blood at the time of the operation.

In a few places, there was evidence of either old or recent hemorrhages in the wall of the cyst. Pockets or clefts were found in the ovary about the site of perforation. These pockets were lined by columnar cells with gland formation and a cellular stroma resembling endometrium (Fig. 4). The patient made a satisfactory recovery. I saw her June 16, 1921. She felt better than she did before the operation, but still had some pain in the lower abdomen. On examination, I found the left ovary to be enlarged and adherent to the side of the pelvis and a small area of induration in the culdesac. I believe that she now has a perforating hemorrhagic cyst of the left ovary with adenoma of endometrial type in the culdesac and may later require another operation.

CASE 12.—*Perforating hemorrhagic cysts of both ovaries, diffuse adenoma of endometrial type involving the posterior uterine wall, the anterior rectal wall and extending laterally into both broad ligaments.*—Mrs. T. H., aged 36, complained of increasing constipation of six months' duration but no pain or other discomfort. She had one child 6 years old. This was the only pregnancy. The menstruation was normal and moderate; there was no pain.

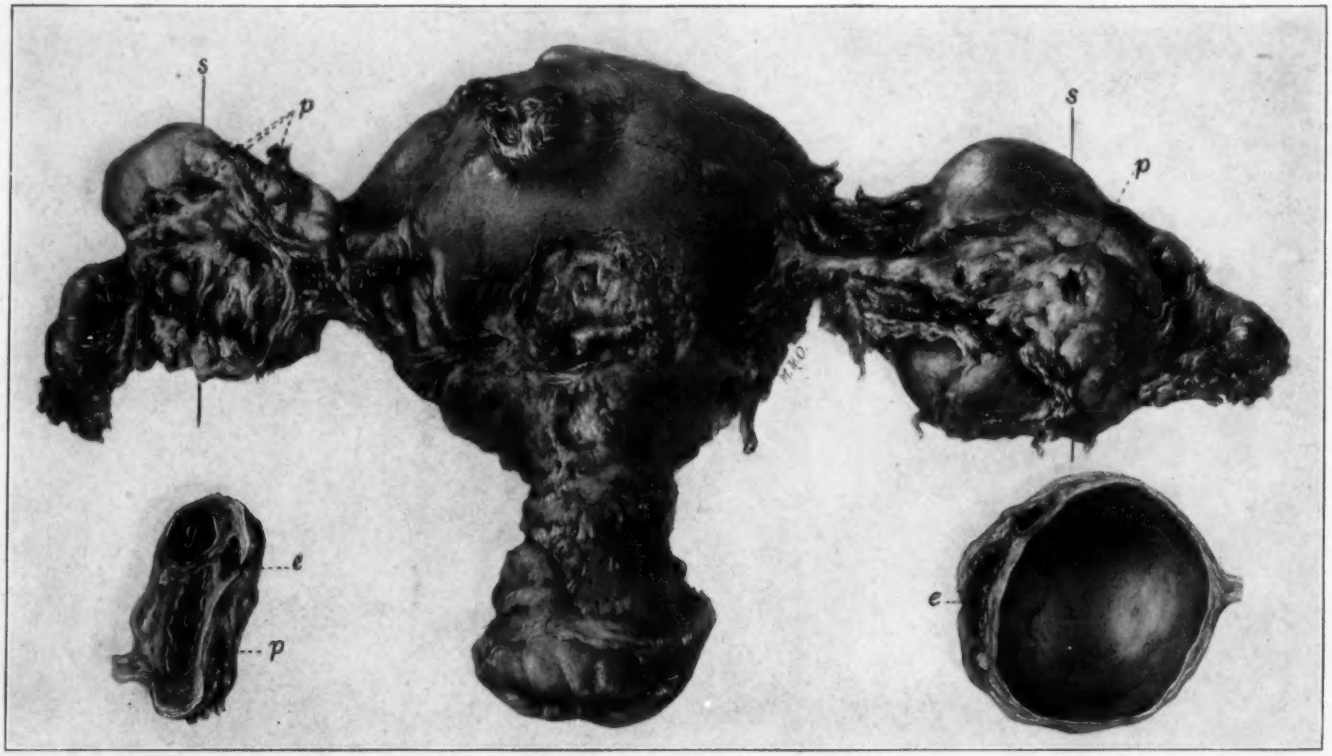


Fig. 54 (Case 19).—Perforating hemorrhagic cysts of both ovaries, adherent retroflexed uterus, small subserous leiomyoma, diffuse adenoma of endometrial type invading the posterior wall of the uterus and also probably the anterior wall of the rectum, adenoma of endometrial type of the sigmoid. Posterior view of the uterus, tubes and ovaries, the latter turned upward showing the perforation (*p*) on the lateral surface of the left ovary and the under surface of the right (natural size). Cross section of the left ovary shows *c*, the hematoma of "endometrial" type (Fig. 57), with perforation at *p*. The small pocket *e* is lined almost entirely with "endometrial" tissue (Fig. 58). The cyst *g* is a graafian follicle hematoma. The cross section of the right ovary shows a small hematoma *e* lined by "endometrial" tissue. The larger cavity is a graafian follicle cyst.

The last flow occurred four days before the operation. Pelvic examination showed the uterus to be slightly enlarged and fixed in the pelvis; there was induration in the culdesac, most marked high up, with distinct bulging into the rectum; this was best detected by rectal palpation. The preoperative diagnosis was dense pelvic adhesions (chronic pelvic peritonitis) with the possibility of implantation of cancer in the culdesac or cancer of the rectum at the junction of the rectum and the sigmoid.

At operation June 8, 1920, both ovaries were enlarged, cystic and adherent. On freeing them, "chocolate" fluid escaped. The uterus was fused to the rectum, with marked induration in both broad ligaments. The diagnosis was evident at the operation, that is, the adhesions and the induration of the broad ligaments were due to an adenoma of endometrial type. The appendix, both tubes and ovaries and the uterus were removed (Fig. 60). The uterus was freed from the rectum with great difficulty, and at the close of the operation,

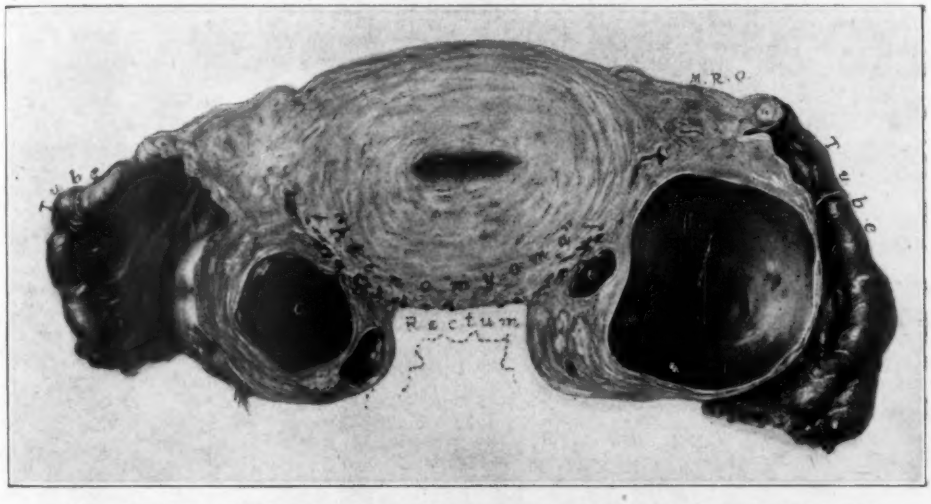


Fig. 55 (Case 19).—Cross section of the uterus and ovaries (natural size) indicating the condition found at operation. Both ovaries were adherent to the posterior surface of the uterus thus sealing the perforations. The adenoma had spread over the surface of the uterus and was just beginning to invade it (Fig. 59). The relation of the rectum to the uterus is indicated by the dotted lines. The larger hematoma, *c*, of the left ovary is shown in longitudinal section, and also the smaller one, *e*, of the right ovary, with the graafian follicle cyst lateral to it. Sections of the uterine wall failed to show any "endometrial" tissue between the superficial growth on its posterior surface and the mucosa of the uterine cavity.

the rectal wall still felt indurated especially over the area marked *x* in Figure 62. Undoubtedly, adenoma was left behind in the anterior wall of the rectum and in the broad ligament. Histologically the cyst of the right ovary was for the most part lacking in an epithelial lining, when present it was low or cuboidal. Columnar epithelium resembling that of the endometrium was found in clefts and pockets in the surface of the ovary about the site of perforation. Adenoma of endometrial type was found invading the posterior uterine wall and giving rise to a definite "adenomyoma" (Figs. 61 and 62). Sections between the "adenomyoma" and the uterine cavity did not show any connection between the two. The patient made a satisfactory recovery and has remained well. There has not been any evidence of an extension of the growth of the adenoma, undoubtedly left in the pelvis and in the anterior wall of the rectum. The patient was examined May 23, 1921. A slight area of induration, about the

size of the end of the examining finger, was palpated in the anterior wall of the rectum. The rectal mucosa was freely movable over it. This area of induration was definitely smaller than at the time of the operation.

CASE 13.—*Perforating hemorrhagic cyst of the right ovary; adenoma of endometrial type invading the posterior wall of the cervix, the vagina and the anterior wall of the rectum.*—Miss E. H., aged 30, complained of severe dysmenorrhea and marked constipation. The menstruation was regular, moderate in amount, always painful, but worse lately. The last flow occurred four weeks before the first operation and the patient was due to menstruate the day of the operation. Pelvic examination showed the uterus to be in normal position with a small definite localized area of induration just back of the cervix. The end of the examining finger just about covered the area which could be detected better on rectal palpation. To the right of this area and above could be felt an adherent cystic mass. The preoperative diagnosis was a

Fig. 56 (Case 19).—Enlargement (× 5) of the upper portion of the left ovary showing the collapsed hemorrhagic cyst *C* (Fig. 57), the endometrial pocket *E* (Fig. 58) and small fragments *M*, loosely attached to the surface of the ovary. These fragments contained "glands" of endometrial type, and should they become dislodged and escape into the peritoneal cavity might give rise to secondary growths of adenoma.

probable perforating hemorrhagic cyst of the right ovary with adhesions in the culdesac.

Operation at the Albany Hospital, June 28, 1920, revealed the left tube and ovary apparently normal. The right ovary was prolapsed and adherent to the side of the pelvis. The lower portion of the culdesac was obliterated by adhesions (Fig. 27). As the patient was very anxious for conservative surgery, I removed only the appendix, the right tube and ovary. Histologically the ovarian cyst was lined by a single layer of cuboidal to columnar epithelium with an underlying vascular stroma into which there was marked hemorrhage, i.e., "premenstrual" hematoma. Glandlike structures resembling uterine glands were present in the wall of the cyst near the site of perforation

(Fig. 29) and also on the surface of the ovary about this site (Fig. 32). Lateral to the cyst was a pocket lined by columnar cells of endometrial type with stroma and recent hemorrhage (Fig. 30). The patient made a satisfactory convalescence. Pelvic examination made before the patient left the hospital showed the same nodule posterior to the cervix, and I realized that it was probably due to adenoma of endometrial type. I saw her again in November, 1920. She had not improved, if anything the menstrual pain was worse. On examination, I found the pelvic condition about the same as before leaving the hospital except the nodule in the culdesac seemed a little larger. The patient was anxious to avoid another operation and decided to wait. She was seen again in March, 1921, and the history was the same as before. On examination, the induration in the culdesac seemed definitely larger.

A second operation was performed March 21, 1921, three weeks after the last menstrual period. On drawing the uterus forward, the anterior wall of the rectum was carried with it in a very characteristic manner (Fig. 33). The culdesac was obliterated to the level of the uterine origin of the uterosacral ligaments, the anterior wall of the rectum having become fused with the supra-

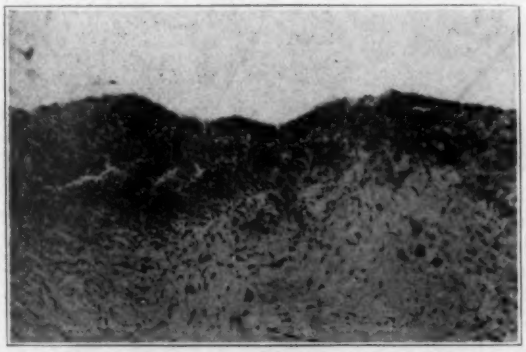

Fig 57 (Case 19).—Photomicrograph of a portion of the wall of the hematoma *C*. The cyst is lined in part by a single layer of epithelium, cuboidal and columnar (columnar epithelium is present in the center of the illustration). Recent hemorrhage is present in the subepithelial stroma, and to the right, the epithelial lining is lacking. The patient was operated on the "last" day of the menstrual period. Compare with Figure 29 (Case 13) when the patient was operated on the day that menstruation was due.

vaginal portion of the cervix up to this point. The rectum was freed from the posterior wall of the cervix, and the entire uterus and the remaining ovary were removed. The patient made a satisfactory convalescence. Histologically an adenoma of endometrial type was found invading the posterior wall of the cervix and to a lesser degree the vagina and the anterior wall of the rectum (Figs. 34, 35 and 36).

CASE 14.—*Perforating hemorrhagic cysts of both ovaries, adherent retroflexed uterus.*—Mrs. H. H., aged 31, complained of sterility. She had been married three years and had never been pregnant. The menstruation was occasionally irregular, extending over the usual period, from seven to ten days; it was always profuse; the last menstrual flow was two weeks before the operation. Pelvic examination showed the uterus to be retroflexed and adherent, as were also the appendages on both sides. There was a slight

degree of induration in the culdesac. The preoperative diagnosis was an adherent retroflexed uterus and possibly bilateral, perforating hemorrhagic cysts of the ovaries.

At operation at the Albany Hospital, July 6, 1920, the uterus was found to be retroflexed and adherent. Both ovaries were cystic and adherent; in freeing the latter, "chocolate" fluid escaped. The tubes appeared normal. The cysts were excised from the ovaries; the appendix removed and the uterus suspended and also curetted. Histologically the cysts were lined by a single layer of epithelium, low, cuboidal and columnar. In some places the epithelium rested directly on the ovarian tissue; in other places there was an intervening vascular cellular stroma; glandlike structures were also present and the histologic picture in some areas of the cyst wall resembled endometrial tissue. Subepithelial hematomas were also present. The patient made a satisfactory convalescence.

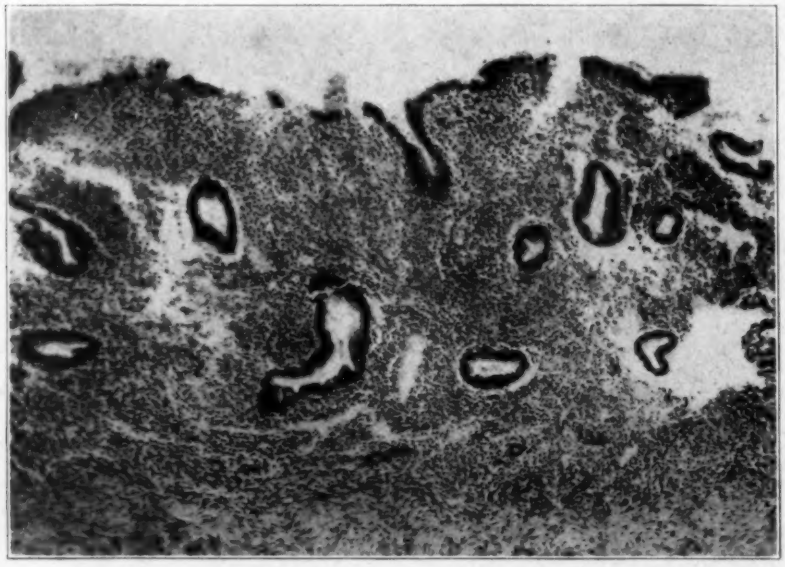

Fig. 58 (Case 19).—Photomicrograph showing the type of tissue lining the "pocket" *e* of the left ovary. One would think it had been removed from the mucosa of the uterine cavity.

CASE 15.—*Perforating hemorrhagic cyst of the right ovary; adherent retroflexed uterus, with a diffuse adenoma of endometrial type superficially involving the greater portion of the posterior wall of the uterus which was densely adherent to the bottom of the culdesac and rectum; intramural leiomyomas.*—Miss M. D., aged 39, complained of uterine bleeding and diarrhea of about six months' duration. The menstruation was regular until about six months before the operation. Since that time the patient had been flowing profusely, without any pain, every two weeks, and it often lasted a week. Diarrhea was of the same duration as the increased menstrual flow with watery bowel movements without pain or blood. Pelvic examination showed the uterus to be retroflexed, slightly enlarged, irregular and adherent. The appendages were not palpated on either side. The preoperative diagnosis was an adherent retroflexed myomatous uterus.

At operation at the Albany Hospital July 12, 1920, the uterus was found retroflexed and densely adherent to the rectum and the bottom of the culdesac (Fig. 42). The left tube and ovary were apparently normal. The right ovary was adherent to the posterior surface of the uterus (Fig. 38). On freeing it, "chocolate" fluid escaped. The appendix, right tube and ovary and the entire uterus were removed. Histologically the ovarian cyst was lined by a single layer of cuboidal to columnar epithelium resting in a cellular vascular stroma (Fig. 39). Recent hemorrhage was present in this stroma. In places, glandlike structures were present which resemble uterine glands. Epithelial tissue was found in the pockets in the surface of the ovary about the site of perforation, which even more closely resembled typical endometrium (Fig. 40). A diffuse adenoma of endometrial type (Fig. 37) had superficially invaded the greater portion of the posterior uterine wall, being present in the area of the uterine wall to which the ovary was adherent at the site of perforation and spreading over the entire area which was adherent to the bottom of the culdesac and the rectum and extending beneath the uterine serosa above this area, forming small blebs.

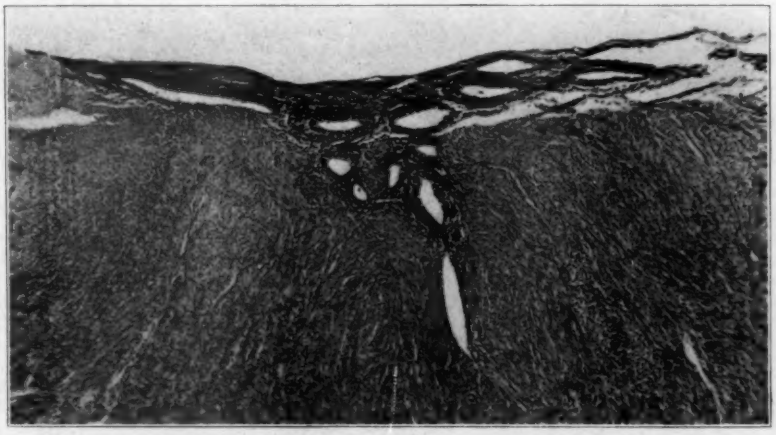

Fig. 59 (Case 19).—Photomicrograph (lower power) of a portion of the posterior wall of the uterus situated just beneath the adherent left ovary. The adenoma resembles a broad headed tack with a short point pushed into (invading) the uterine wall. The tissue lining, the hematoma *c*, the pocket *e* and that shown in this illustration all represent the same process as altered by physical conditions.

Histologically the lining of the hemorrhagic cyst, the tissues in the ovarian clefts about the site of perforation and the diffuse growth involving the posterior surface of the uterus were similar, except that in the ovary it was an adenocystoma of endometrial type with the cystoma feature predominating while in the uterus the adenomatous feature prevailed. The patient made a slow but satisfactory recovery, but died about six months later. The cause of death was not determined.

CASE 16.—*Perforating hemorrhagic cyst of the left ovary, retroflexed uterus; slight adhesions about the left ovary; chronic appendicitis.*—Mrs. J. W., aged 31, complained of pain in the right side in repeated attacks during the last ten years. She had one child, 5 years old, and possibly had a miscarriage one and one-half years ago. The menstruation was always profuse and painful. Pelvic examination showed the uterus to be retroflexed but freely movable. The preoperative diagnosis was chronic appendicitis and retroflexed uterus.

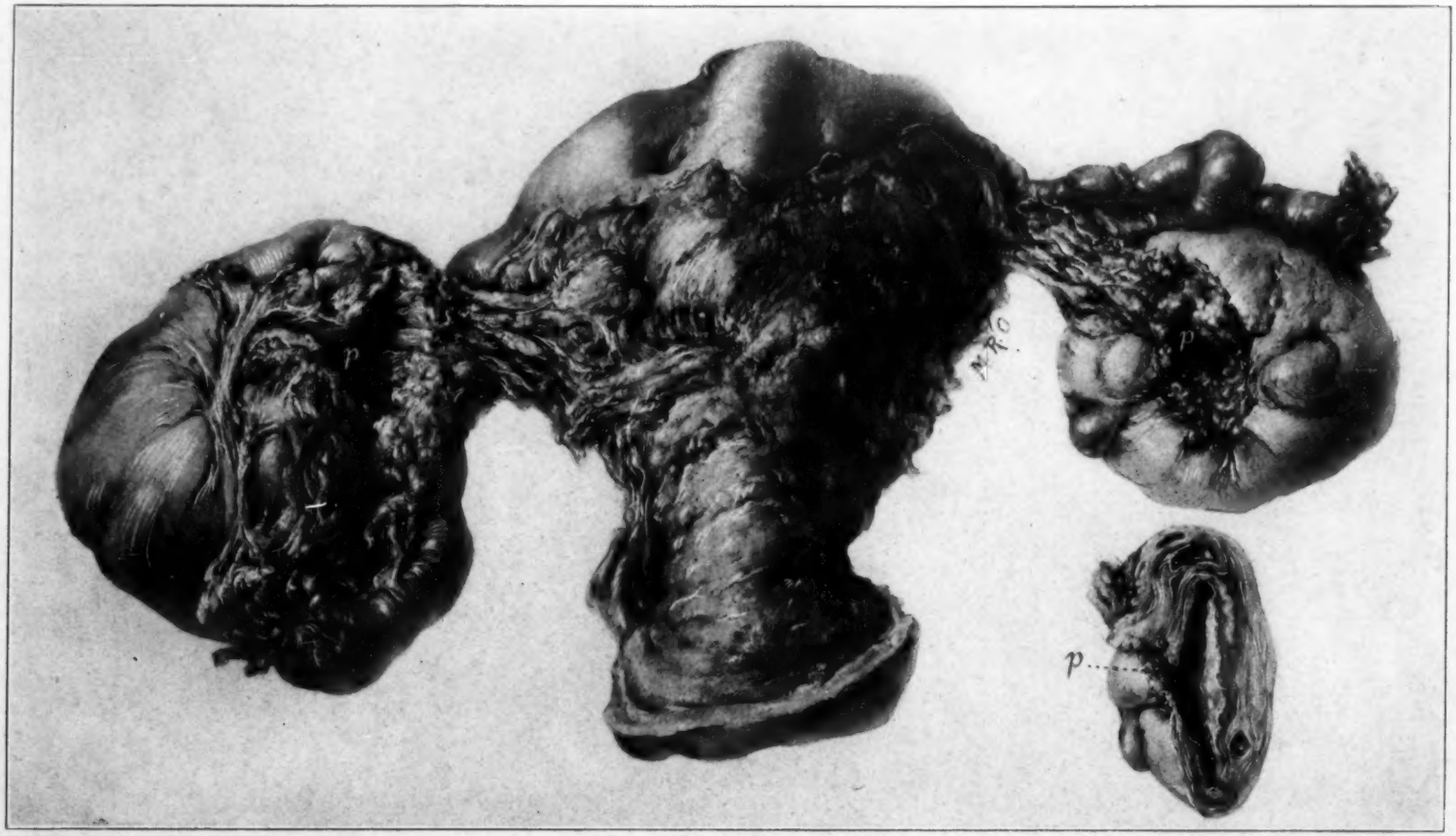


Fig. 60 (Case 12).—Perforating hemorrhagic cysts of both ovaries; adenoma of endometrial type of the posterior uterine wall uniting it to the rectum and extending laterally into both broad ligaments. Posterior view of the uterus, tubes and ovaries (natural size). The uterus was separated from the rectum with great difficulty and purposely some of the uterine tissue was left attached to the anterior wall of the rectum; hence the rough and ragged appearance of the uterus. The left ovary contains a graafian follicle cyst about 6 cm. in diameter with a smaller perforating hemorrhagic cyst on its lateral surface. The right ovary contains a collapsed hemorrhagic cyst perforating on its under surface. Histologically, the right cyst was the exact counterpart of the condition shown in Figures 3 and 4 (Case 11), namely, a hematoma of probable endometrial type in which recognizable "endometrial" tissue was found only in pockets in the periphery of the ovary about the perforation.

At operation at the Albany Hospital Oct. 28, 1920, the appendix which was adherent was removed. The uterus was retroflexed but freely movable. The left ovary was cystic and adherent. On freeing it, "chocolate" fluid escaped. The hematoma was excised from the left ovary, and the uterus suspended and curetted. Histologically, the cyst was lined by a single layer of cuboidal epithelium. Pockets of clefts were found in the ovary about the site of perforation which were lined by columnar epithelium with gland formation resembling endometrium. The patient made a satisfactory recovery and has remained well.

CASE 17.—*Perforating hemorrhagic cysts of both ovaries; adherent retroflexed uterus; multiple small leiomyomas; discrete superficial "adenomyomas" in the posterior uterine wall where the left ovary was adherent at the site of its perforation and adenoma beneath the adherent right ovary.*—Mrs. C. A. P.

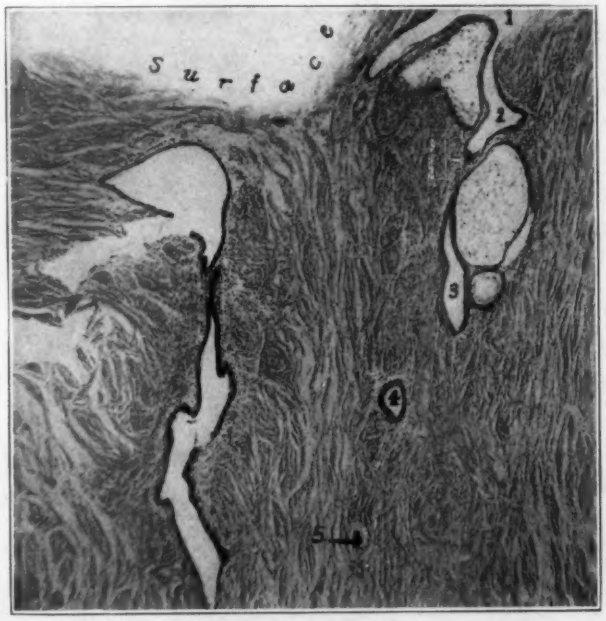


Fig. 61 (Case 12).—Photomicrograph of a portion of the posterior wall of the uterus beneath the attachment of the right ovary. The adenoma has invaded the uterus from the peritoneal surface like a long pointed crooked tack in which the head had probably been torn off during the operation. Compare with Figure 59 (Case 19).

aged 38, complained of uterine bleeding. She had been married eight years but had never been pregnant. The menstruation was regular, painless and always profuse, but more so lately. There had been irregular "spotting" for the last nine months. Pelvic examination showed the uterus to be retroverted, irregular in outline and apparently adherent. The appendages were not palpated. A slight area of induration could be palpated in the culdesac, apparently in the posterior wall of the uterus. It was detected best on rectal palpation. The preoperative diagnosis was an adherent retroverted uterus with small myomas.

At operation at the Albany Hospital Dec. 7, 1920, the uterus was found to be retroverted and adherent. Both ovaries were cystic and adherent to the posterior surface of the uterus. On freeing the ovaries, "chocolate" fluid

escaped. The appendix, both tubes and ovaries and the entire uterus were removed (Fig. 43). The tubes were normal. Histologically both hemorrhagic cysts contained a pigmented wavy "luteal" layer with evidence of "regeneration" of the epithelial lining of the cysts from the periphery of the ovary at the site of perforation. In the clefts in the ovary were areas of epithelial cells resembling endometrium. The area (Fig. 44) of the posterior uterine wall which was adherent to the left ovary showed a discrete nodule of "adenomyoma" (Fig. 46). Adenoma of endometrial type was found beneath the adherent right ovary (Figs. 44 and 45). The patient made a satisfactory convalescence and has remained well.

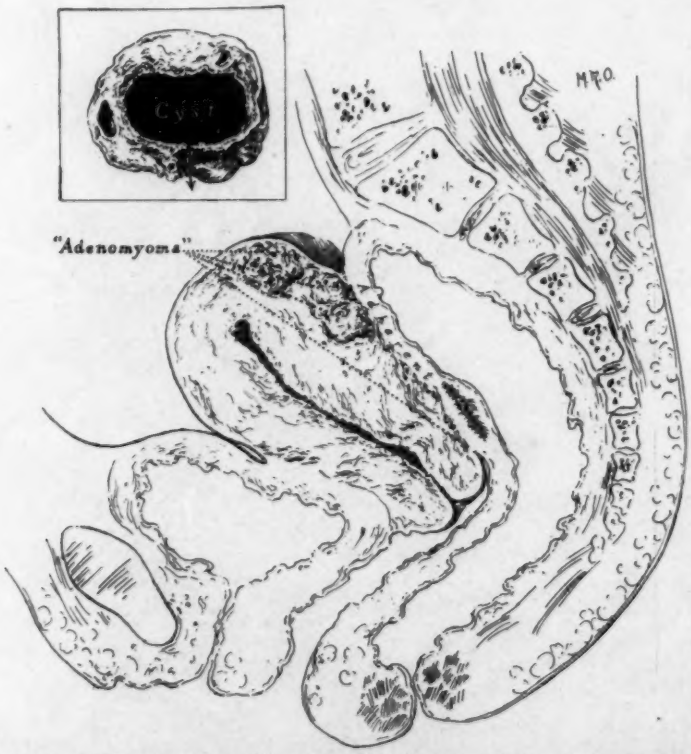


Fig. 62 (Case 12).—Sagittal section of the pelvis showing relation of the "adenomyomatous uterus" to the rectum prior to the operation; × ½. The adenoma arising in the culdesac "due to the escape of the contents of the cyst" has invaded the posterior wall of the uterus forming a definite "adenomyoma" of the fundus and uniting the uterus to the rectum and superficially invading that organ. The area marked *x* indicates a distinct nodule felt in the anterior rectal wall prior to, and also during, the operation. This nodule or thickening was not removed. The rectal mucosa over it was freely movable, and I believe it is a nodule of adenomatous tissue in the rectal wall. It is interesting to await its ultimate fate; so far it has not caused any trouble.

CASE 18.—*Perforating hemorrhagic cyst of the right ovary; multiple small leiomyomas of the uterus; adhesions between the uterus and the rectum with adenoma of endometrial type involving the posterior wall of the uterus and also the posterior surface of the right broad ligament.*—Mrs. H. K., aged 37, complained of marked constipation. She was married but had never been pregnant. The menstruation was regular, moderate and painless. Pelvic examination showed the uterus to be irregularly enlarged and adherent,

with an area of marked induration in the culdesac between the uterus and the rectum. This induration was very evident on rectal palpation and had led to a previous diagnosis of possible malignancy by another physician. The appendages on the left side were enlarged and cystic; those on the right were not palpated. The preoperative diagnosis was perforating hemorrhagic cyst of the left ovary with culdesac adhesions and adenoma of the endometrial type.

Operation at the Albany Hospital Dec. 8, 1920, revealed the uterus irregularly enlarged by multiple leiomyomas and the left ovary enlarged with multiple retentive cysts but freely movable. The right ovary was normal in size and adherent to the side of the pelvis. On freeing it, "chocolate" fluid escaped. The tubes appeared normal. The appendix, the left tube and ovary, the right tube, the greater portion of the right ovary and the entire uterus were removed. Microscopically, the cyst in the right ovary was lined by a single layer of epithelium of low and cuboidal type with a very vascular underlying stroma. In places the cyst wall suggested the remains of a "luteal" layer. Pockets or clefts were found in the ovary about the site of perforation. These pockets were lined by columnar epithelium with gland formation and a stroma resembling endometrium. Similar tissue was also found on the posterior surface of the right broad ligament. Not enough tissue from the uterus was examined to determine the extent of the adenoma involving its posterior surface. Only one section was made from this area; adenoma was found in this section but unfortunately the entire specimen was not saved for further sections. The patient made a satisfactory convalescence except for a slight infection of the lower end of the abdominal incision. The end-result of saving ovarian tissue in this case will be watched with interest.

CASE 19.—*Perforating hemorrhagic cysts of both ovaries; diffuse adenoma of endometrial type involving the posterior wall of the uterus, the anterior wall of the rectum, both broad ligaments and forming two separate nodules in the sigmoid ("adenomyoma" of the sigmoid).*—Mrs. J. W., aged 45, complained of marked constipation with attacks of obstruction beginning two years before the operation and gradually increased in severity. She had two children, the youngest 6 years old. The menstruation was regular, moderate and without pain until the last two years. During this time pain had been present, increasing in severity, and the flow had been decreasing in amount. The patient was operated on the last day of the flow. It is of great interest to note that the attacks of the most marked constipation occurred with the menstrual period. These had been especially bad during the last year. The pain was so severe the patient had to remain in bed; the abdomen often became distended, and sometimes there were nausea and vomiting. Bowel movements were obtained only with the greatest difficulty. No blood was ever observed in the evacuations. The abdomen remained tender for about a week after the cessation of the flow. Pelvic examination showed the uterus to be irregular, adherent and retroverted. The appendages were not palpated. Rectal palpation confirmed these findings. No localized induration was detected in the culdesac. Roentgenograms following a barium enema were made but no definite point of obstruction was found. The preoperative diagnosis was an adherent myomatous uterus with possibly a malignant growth of the sigmoid. The true condition was not considered.

At operation at the Albany Hospital Feb. 17, 1921, the uterus, containing small leiomyomas, was found retroverted and adherent to the rectum. A small amount of "old blood" was found free in the pelvis. Both ovaries were cystic

enlarged and adherent to the posterior surface of the uterus. On freeing the ovaries, "chocolate" fluid escaped. Two definite puckered areas were found in the sigmoid. One area was situated just above the apparent rectosigmoidal junction and the other about 8 cm. above this one. The upper area was not involved in or continuous with the adhesions uniting the uterus to the sigmoid or those between the ovaries and the uterus. On palpating each of these puckered areas, a definite nodule could be distinctly felt, apparently projecting into the lumen of the sigmoid. The upper one was the larger. The correct diagnosis was now apparent. The appendix was first removed, then both tubes and ovaries and the entire uterus (Figs. 54 and 55). The separation of the uterus from the rectum was extremely difficult for apparently the growth had invaded it and also the broad ligament on both sides. The upper and larger nodule in the sigmoid was excised and an end-to-end suture of the intestine made. Histologically the larger cyst of the left ovary was in part lined by a single layer of epithelium, the cuboidal type predominating, with evidence

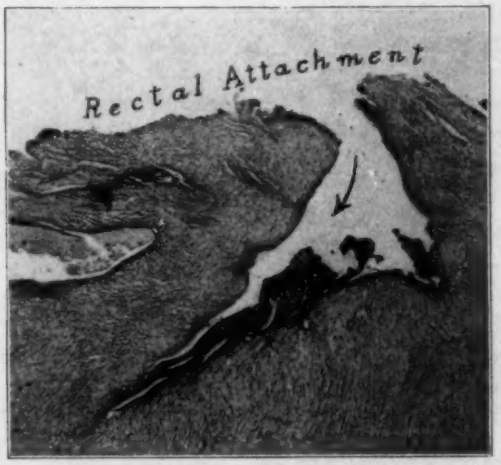


Fig. 63 (Case 3).—Photomicrograph of a section of the posterior wall of the uterus showing the ragged surface caused by freeing the uterus from its attachment to the rectum and also the apparent invasion of the uterine wall from its peritoneal surface (i. e., from "without") by adenoma of endometrial type. Perforating hemorrhagic cysts were present in both ovaries.

of recent hemorrhage into the underlying stroma (Fig. 57). Adenoma of endometrial type was found lining the smaller cyst or pocket (Fig. 58) and also on the surface of the ovary, between it and the uterus. The larger cyst of the right ovary was a graafian follicle cyst, but the smaller hemorrhagic cyst or pocket was lined by an adenoma of normal endometrial type; adenoma of endometrial type was found on the surface of the uterus superficially invading its posterior wall (Fig. 59). A similar adenoma was found invading the wall of the sigmoid on its peritoneal surface, extending through the entire wall into the submucosa. The patient made a satisfactory convalescence and has remained well. The end-result is awaited with great interest to determine the fate of the adenoma, undoubtedly still present in the sigmoid and the culdesac.

CASE 20.—*Perforating hemorrhagic cyst of the right ovary; multiple pelvic adenoma of endometrial type; cancer of the uterine cervix.*—Miss A. N., aged 41, complained of irregular uterine bleeding of three months' duration. The menstruation had been regular, moderate and painless. On account of the irregular uterine bleeding during the last three months, it was impossible to determine recent menstrual dates. There were no symptoms referable to the pelvic adenomas. Pelvic examination showed a friable everting growth occupying the vaginal portion of the cervix, especially the posterior lip. The uterus was freely movable, a definite nodule could be detected posterior to the cervix; this was more evident on the left side and best felt on rectal palpation. The preoperative diagnosis was everting type of cancer of the uterine cervix with possible extension posteriorly on the left side.

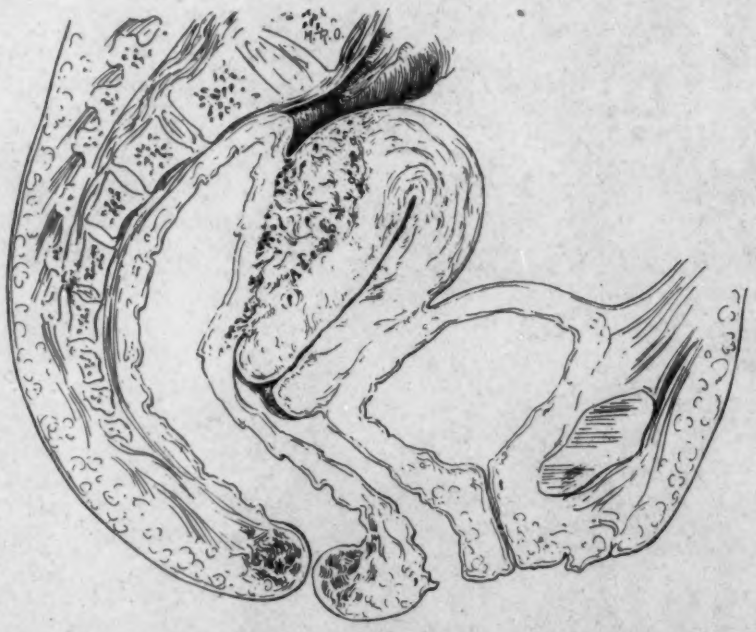

Fig. 64 (Case 2).—Perforating hemorrhagic cysts of both ovaries, diffuse "adenomyoma" of the posterior uterine wall which is fused with the anterior wall of the rectum. Sagittal section of the pelvis; × ½. The "adenomyoma" is apparently not connected with the mucosa of the uterine cavity. I believe this case represents an advanced stage of the conditions shown in the previous illustrations, namely, an "adenomyoma" of the uterus due to the invasion of the uterine wall by adenoma of endometrial type from the culdesac secondary to the escape of the contents of the hemorrhagic cysts into the pelvis.

At operation at the Albany Hospital March 1, 1921, the uterus was found to be freely movable, the right ovary was cystic and adherent to the posterior surface of the uterus. On freeing it, "chocolate" fluid escaped. The lower portion of the ureters and the bladder was freed, and the entire uterus was removed with a wide excision of the parametrium. The lymph nodes about the iliac vessels were also removed. Histologically, the cancer proved to be of the squamous cell variety; the lymph nodes removed did not show cancer. The right ovary contained a hematoma partly lined by the remains of a wavy pigmented layer and with an epithelial lining of the portion of the cyst wall

not occupied by the pigmented layer. Adenoma of endometrial type was also found in the periphery of the ovary about the site of perforation. Secondary adenoma of endometrial type was present in the culdesac just mesial to the left uterosacral ligament (Figs. 71, 72 and 74), in the surface of the posterior uterine wall where it was adherent to the ovary, and on the anterior surface of the uterus in the vesico-uterine fold of peritoneum, just beneath the left round ligament and also to the right of the median line (Fig. 73). The left ovary showed on its under surface a cleft lined by "endometrial" tissue. The patient made a satisfactory convalescence.

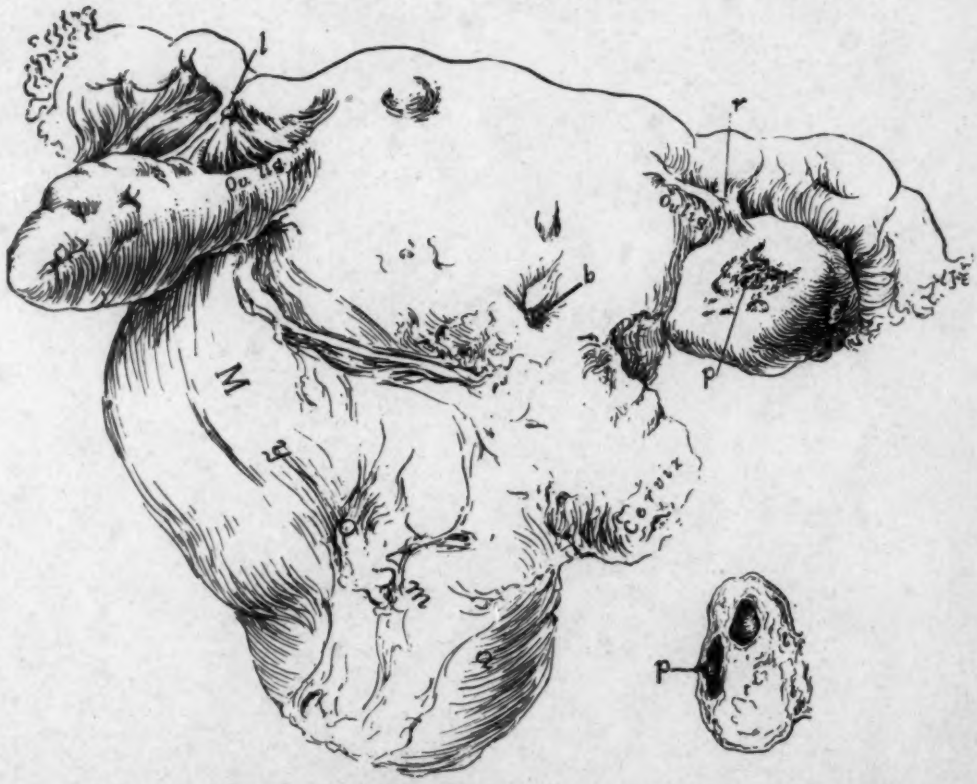


Fig. 65 (Case 22).—Perforating hemorrhagic cyst of the right ovary; multinodular myomatous uterus, deposits of adenoma (endometrial type) on the posterior and anterior surface of both broad ligaments and in the culdesac (the latter deposit not removed), multiple peritoneal blebs (adenomatous) on the anterior and posterior surfaces of the uterus and left broad ligament and in the vesico-uterine fold. Posterior surface of the uterus; × ⅔. The perforation *p* on the under surface of the right ovary is shown with raw area about it caused by freeing it from the posterior surface of the uterus to which it was adherent at *b*. The ovary is also shown in cross section. A hemorrhagic bleb with puckering of the tissue about it (excised for microscopic examination, but unfortunately lost) is indicated at *b*. A puckering of the right broad ligament between the tube and the ovarian ligament is shown—adenoma of endometrial type was found in this tissue (Fig. 67). A similar puckering is shown of the left broad ligament just beneath the tube, adenoma of endometrial type was also present here.

CASE 21.—*Perforating hemorrhagic cyst of the right ovary; adherent retroflexed uterus with diffuse adenoma of endometrial type involving the posterior surface of the uterus and the anterior wall of the rectum.*—Mrs. T. E., aged 44, complained of marked constipation, much worse at the menstrual

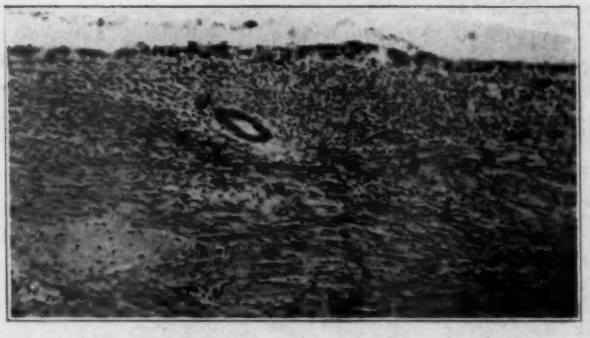

Fig. 66 (Case 22).—Photomicrograph of the wall of the ovarian hematoma showing that it is lined by a single layer of columnar cells with an underlying cellular stroma containing a "gland." It is a hematoma of "endometrial" type and the escape of its contents was the probable cause of the many adenomas of endometrial type found in the adhesions between the folds of peritoneum about the uterus and in the culdesac and also of some, and possibly all, of the peritoneal "blebs" on the surface of the uterus and its ligaments.

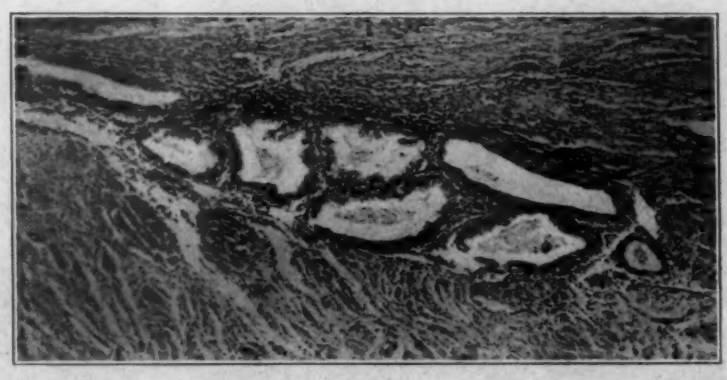

Fig. 67 (Case 22).—Photomicrograph of the puckered right broad ligament shown in Figure 65. Adenoma of endometrial type has developed between the adherent folds of the ligament.

period, especially the last year. She also had indigestion. She had been married six years and had never been pregnant. Menstruation was regular, moderate in amount, occasionally accompanied with slight pain. The constipation was much worse at that time. The last flow occurred two weeks before the operation. Pelvic examination showed the uterus to be retroflexed and adherent, with a distinct area of induration back and above the cervix between the uterus and the rectum. The appendages were not palpated. Preoperative diagnosis was adherent retroflexed uterus, possible perforating hemorrhagic ovarian cyst with adenoma of the culdesac.

Operation was performed at the Albany Hospital March 21, 1921. A median incision was made; the gallbladder was palpated and a stone was felt. The uterus was retroflexed and adherent to the rectum. On drawing the uterus forward, the anterior rectal wall was carried with it. The right ovary was adherent to the side of the pelvis, directly over the course of the right ureter.

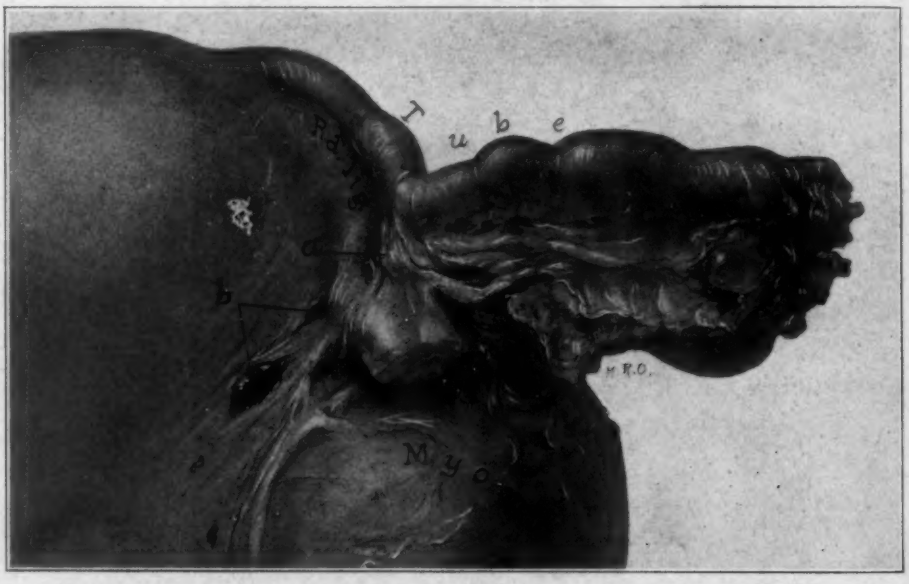


Fig. 68 (Case 22).—"Adenomyoma" of left round ligament with adhesions of the anterior layer of the broad ligament to it, multiple hemorrhagic peritoneal "blebs" (adenomatous). Anterior surface of the left uterine cornu, left tube and round ligament. The anterior surface of the broad ligament is puckered, drawn down and adherent to the round ligament (Fig. 69). The "blebs," many hemorrhagic, with puckering of the tissue about them are similar to the one shown in Figure 70.

On freeing the ovary, "chocolate" fluid escaped. The left ovary seemed normal. Both tubes appeared normal. The appendix, right tube and ovary and the entire uterus were removed (Fig. 16). The gallstone was removed and the gallbladder drained. The left tube and ovary were not removed because the patient was exceedingly nervous, and the ovary appeared normal. I am awaiting the end-results in this case with interest to see whether or not such ovarian conservatism is justifiable. I fully realized at the time that these cysts are often bilateral and that later she may have a similar condition in the left ovary with secondary growths in the pelvis, or the retention of the ovary may stimulate adenomatous deposits which may have been left in the pelvis

at the operation. Histologically the deeper portion of the ovarian cyst was lined by the remains of a pigmented "luteal" layer without an epithelial covering (Fig. 17). The portion of the cyst not occupied by the "luteal" layer was lined by a single layer of columnar epithelium with an underlying vascular stroma (Fig. 19). In the edges of the perforation and in the periphery of the ovary about the site of perforation were deposits of glandular tissue with cellular stroma closely resembling endometrium (Fig. 18). The histologic study of the entire ovary suggested that either the initial rupture of the cyst had been followed by its invasion by epithelium of endometrial type from the periphery of the ovary or else it represents the regeneration of the epithelial lining of an "endometrial" cyst after a hemorrhage. This epithelium extended through the perforation and was relining the cyst. At the same time the "luteal" layer was retrogressing (Fig. 20) and eventually the cyst might be converted into a cyst lined entirely by epithelium of the endometrial type. Adenoma of endometrial type was found in the tissue of the side of the pelvis which was adherent to the ovary at the site of rupture, also in a nodule in the vesico-

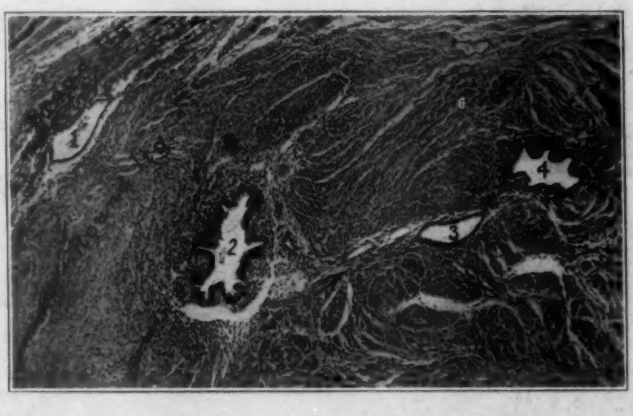


Fig. 69 (Case 22).—Photomicrograph of the left round ligament and the adherent broad ligament shown in Figure 68. Adenoma of endometrial type has developed in the peritoneal fold between the two ligaments 1, and has invaded the round ligament causing an "adenomyoma" of that structure.

uterine fold of peritoneum and over a large area of the posterior uterine wall (Figs. 21, 22, 23, 24 and 25) and the anterior wall of the rectum which were adherent to each other (Fig. 26). The patient made a satisfactory recovery.

CASE 22.—*Perforating hemorrhagic cyst of the right ovary; multiple leiomyomas of the uterus; multiple small adenomas of endometrial type on the posterior and the anterior surfaces of the broad ligaments.*—Mrs. A. D., aged 41, complained of pain in the left side, dysmenorrhea and constipation. She had had two children, 13 and 10 years of age. Menstruation was regular, moderate in amount and painless until three years ago. Pain had been present for three years, gradually increasing in severity so that she remained in bed for the first day of the flow. The last flow was three weeks before the operation. Pelvic examination showed an irregular, enlarged uterus with the largest nodule low in the pelvis and to the left side of the cervix. Movements of the uterus were restricted. Preoperative diagnosis was an adherent multinodular myomatous uterus.

Operation at the Albany Hospital April 7, 1921, under nitrous oxid and oxygen anesthesia (patient was a diabetic), revealed a multinodular, myomatous uterus, with the largest nodule about 9 cm. in its greatest diameter, extending between the layers of the left broad ligaments. The right ovary was found adherent to the posterior surface of the uterus, and in freeing it, a small amount of "chocolate" fluid escaped. A small nodule with puckering of the surrounding tissue was found on the posterior surface of both broad ligaments between the ovaries and the tube, a similar nodule was also present in the culdesac (not removed). A small hemorrhagic bleb, about 6 mm. in diameter with puckering of the tissues about it, was found on the part of the posterior surface of the uterus which had been adherent to the right ovary at its site of perforation. Similar blebs were found on the anterior surface of the left broad ligament and about the round ligament. The left broad ligament was puckered and adherent to the round ligament drawing the tube down toward it (Fig. 68). The tubes, ovaries, uterus and nearly the entire cervix were removed (appendix removed at a previous operation). Histologically, the cyst of the

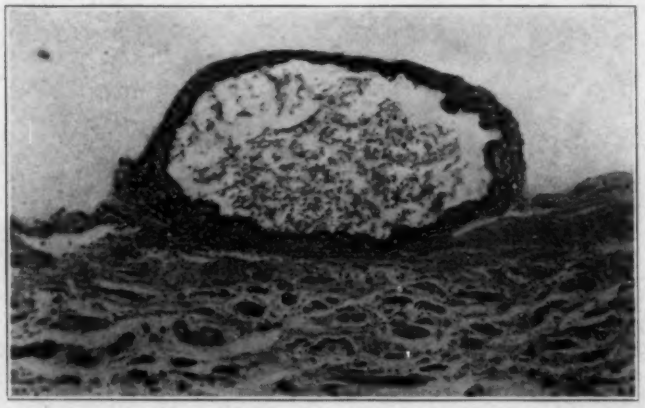

Fig. 70 (Case 22).—Photomicrograph (lower power than preceding) of one of the smaller peritoneal blebs or cysts shown in Figure 68. It is lined by columnar cells resting on a cellular stroma. Histologically, it is an "endometrial" cyst and similar to the cyst partially detached from the ovary shown in Figure 49 (Case 23). The other peritoneal cysts indicated in Figure 68 were examined microscopically and showed a similar condition. If these blebs are of endometrial type and are derived from the contents of the ovary, what is their development? Three possible explanations suggest themselves: first, from the deposit of epithelial cells from the ovary on the peritoneum and their subsequent development into a cyst as shown in Figure 22 (Case 21); second, a small cyst or dilated gland may have been detached from the ovary as shown in Figures 32 and 56 (*M*), and may be implanted on the peritoneum and then increase in size, and third, the "specific" irritation of the contents of the ovary caused a metaplasia of the peritoneal endothelium giving rise to a cyst of endometrial type.

right ovary was lined by columnar cells with a vascular stroma and in places gland formation. The histologic structure of this cyst was that of a cystoma of the endometrial type (Fig. 66). The nodules in the broad ligaments showed adenoma of endometrial type (Fig. 67), the one on the anterior surface of the left broad ligament had invaded the round ligament forming an "adenomyoma" (Fig. 69). The blebs were interesting in that they were lined by low, cuboidal and columnar epithelium with a vascular underlying stroma (Fig. 70). The supporters of the serosal origin of adenomyoma would probably interpret them as the development of adenomyoma from metaplasia of the peritoneal "endo-

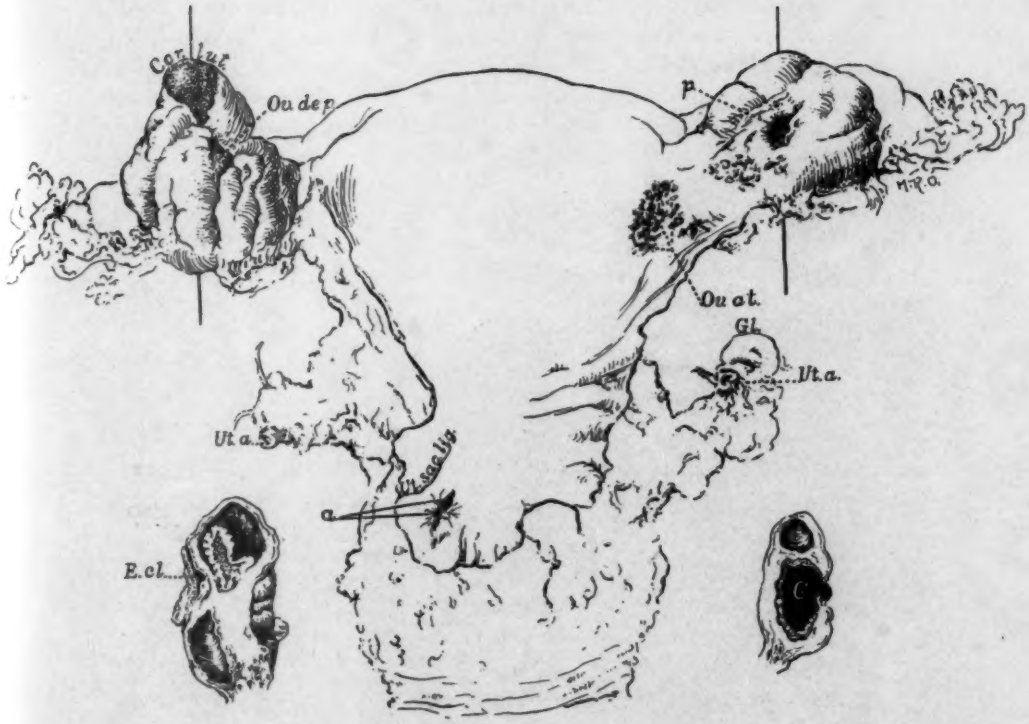


Fig. 71 (Case 20).—Perforating hemorrhagic cyst of the right ovary; adenoma of endometrial type near the left uterosacral ligament below the left round ligament and in the vesico-uterine fold; cancer of the uterine cervix. Posterior surface of the uterus, tubes and ovaries; × ⅜. The right ovary was adherent to the posterior surface of the uterus at *Ov.* Its perforation (*p*) is situated on the lateral surface. On the lateral surface of the left ovary is a small pigmented area *ov. dep.* beneath which is a space lined by columnar epithelium. *Gl.* represents a parametrial lymph node. Just mesial to the left uterosacral ligament is an indurated area with puckering of the peritoneum about it. Small pigmented cysts can be seen in this tissue (Figs. 72 and 74). Histologically, portions of the right ovarian hematoma, the epithelial cleft in the left ovary and the nodules near the left uterosacral ligament, left round ligament and in the vesico-uterine fold are similar, namely, adenocystomas of endometrial type, apparently primary in the ovaries with secondary deposits in the other places.

thelium." For further description of the findings in this case see the illustrations with their legends. The patient made a satisfactory recovery.

CASE 23.—*Perforating hemorrhagic cyst of the left ovary; adherent retroflexed uterus with adenoma of endometrial type involving the posterior surface of the cervix, uniting the latter to the bottom of the culdesac and the rectum and extending through the vaginal wall and presenting as a hemorrhagic cyst in the vaginal vault behind the cervix.*—Mrs. G. H., aged 47, complained of bearing down sensations. She had had four children, the youngest 10 years of age. Menstruation was regular, moderate in amount and painless. The last flow occurred two weeks before the operation. She was not constipated. Pelvic examination showed a weakened pelvic floor, uterus retroflexed and adherent, with a small nodule in the posterior vaginal vault just back of the cervix, and to the left of the median line. A definite nodular induration was felt in the bottom of the culdesac between the cervix and the rectum. The appendages on the right side felt normal, while the left appendages seemed enlarged and adherent. The preoperative diagnosis was an adherent retroflexed uterus, perforating hemorrhagic cyst of the left ovary and adenoma of endometrial type in the bottom of the culdesac and extending through the vaginal vault.

Fig. 72 (Case 20).—Indurated area mesial to left uterosacral ligament containing small cysts (Fig. 73). Note the puckering of the peritoneum about this area, see Figure 74. (I have not yet been able to demonstrate the development of this type of lesion as I have that shown in Figure 24.)

At operation at the Albany Hospital April 18, 1921, the uterus was found to be retroflexed and adherent The omentum was adherent to the left ovary and the left round ligament. The left ovary was cystic, drawn up over the left tube and adherent at the point of rupture to the left round ligament and omentum (Fig. 47). The right tube and ovary were freely movable. On drawing the uterus forward, the anterior wall of the rectum, which was adherent to the supravaginal portion of the cervix, was carried with it in a characteristic manner. On freeing the omentum and left ovary, "chocolate" fluid escaped (Fig. 48). The appendix, both tubes and ovaries and the entire uterus were removed, and the pelvic floor was repaired. Histologically, the ovarian cyst was in part lined by cuboidal and columnar epithelium, columnar predominating with a vascular underlying stroma (Fig. 49) and evidence of old and recent hemorrhages. In other places, there was a wavy membrane filled with pigmented cells lining the cavity and without an epithelial covering, the probable results of hemorrhage into the wall of the cyst. Sections through the posterior wall of the cervix

and the vagina showed that these structures were invaded by an adenoma of endometrial type (Fig. 53), which at the time of operation was found filled with old blood forming small cavities. Adenoma of the endometrial type was also found in a fold of the peritoneum about the left round ligament where the perforating cyst had been sealed (Fig. 51). Histologically, the process in the ovary, the fold of the peritoneum about the round ligament, the posterior wall of the supravaginal portion of the cervix and the posterior vaginal wall are the same, namely, an adenoma of endometrial type. The patient made a satisfactory recovery.

## CONCLUSIONS

Perforating hemorrhagic cysts of the ovary occur most frequently in women between 30 years of age and the menopause. In the twenty-three cases reported in this paper, only two were under 30 and the oldest patient was 47. It is quite a common condition, probably occurring in nearly 10 per cent. of the women of these age limits who require abdominal operations for the relief of pelvic disease. During the year, May 1, 1920, to May 1, 1921, I found perforating hemorrhagic cysts of the ovary in fourteen of 178 patients between 30 and 50 years of age who had an abdominal operation for some disease of the pelvic organs.

The cysts are usually small, between 2 and 4 cm. in diameter, occasionally less than 2 and also occasionally larger than 4 cm. They are quite frequently bilateral, as in eight of the twenty-three cases.

At operation the cyst or ovary is found to be adherent, and in freeing it the "chocolate" contents escape because a previous perforation, which had been sealed by whatever structure the ovary had become adherent to, is reopened or the cyst is torn. Adhesions, due to the "irritating" action of the material which had previously escaped from the ovary, are always present, and these vary greatly in location, density and extent. They may be found in any of the natural pockets and folds of the pelvis where such material would be apt to lodge, and especially in the culdesac. When slight, they simulate the adhesions resulting from pelvic peritonitis of tubal origin; on the other hand, the adhesions in the culdesac may be accompanied by such a marked reaction as to resemble malignancy.

The histologic findings in these cysts vary in different specimens and in different portions of the same cyst. With my present knowledge of their life history, I prefer to state "possibilities" rather than make definite statements which may later prove to be incorrect. There may be several varieties of these cysts; but I am more inclined to believe that most of the apparently different kinds represent various stages in the development and retrogression of one type of cyst and the various phases in its "menstrual" cycle. The initial perforation may have

Fig. 73 (Case 20).—Adenoma of endometrial type in the vesico-uterine fold just below the left round ligament. Sagittal section of the uterus; × ⅓. *A* indicates the situation of a small pigmented nodule with puckering of the peritoneum about it. A similar nodule was present in the vesico-uterine fold to the right of the midline corresponding to *X* in the illustration. Histologically, these nodules were similar to the one near the left uterosacral ligament (Fig. 74).

Fig. 74 (Case 20).—Enlargement (× 10) of a stained section of the indurated area mesial to the left uterosacral ligament (Figs. 71 and 72). Cystlike cavities are present which are lined by tissue of endometrial type and with evidence of former hemorrhage as shown by pigmented cells in their walls.

been the rupture of an "endometrial," graafian follicle or atretic follicle hematoma; or following ovulation, an abnormal corpus luteum may have developed due to the invasion of "endometrial tissue" present at the site of rupture. One group of these perforating hemorrhagic cysts shows these conditions: A portion of the hematoma, usually the deeper, is lined by a "luteal" membrane the exact origin of which in some specimens is difficult to state. The rest of the cyst, usually toward the perforation, is apparently being relined by the invasion of epithelium, through the perforation, from epithelium situated in the periphery of the ovary at the site of rupture. This epithelial relining or regeneration is of endometrial type, both in structure and in function. With the advance of the epithelial invasion, the "luteal" membrane retrogresses, and eventually the entire cyst may be relined by this epithelial tissue. This group represents either the development of an "endometrial" cyst from the invasion of a follicular hematoma by misplaced "endometrial" epithelium or else it represents the regeneration of an "endometrial" cyst after a hemorrhage ("menstrual"). Another group apparently represents either an earlier or a later stage of the former. The cysts in this group are entirely lined with epithelium, low, cuboidal or columnar; all three types of epithelium are often present in the same cyst. Usually there is a vascular cellular stroma not unlike that of the endometrium, between the epithelium and the ovarian tissue, often with evidence of old and recent hemorrhage. This stroma varies greatly in thickness and in some instances may be very thin or lacking. Structures, like uterine glands, may be present in this stroma, and these are usually most numerous near the site of the perforation. The entire cyst is like the epithelial portion of the cysts described in the first group, and all gradations between the two groups may be found.

The exact counterpart of the epithelial lining of these ovarian hematomas may be found in the uterine hematomas often occurring in "adenomyoma" of the uterus and apparently due to the retention of menstrual blood. Tissue of endometrial type is also present in pockets in the periphery of the ovary about the perforation, and the tissue in these pockets may resemble normal endometrium more closely than that lining the hematoma in the same ovary. The histologic study of these hematomas shows that periodic hemorrhage similar to that of menstruation occurs. I have come to the conclusion that these ovarian hematomas are of endometrial type just as are the uterine hematomas found in "adenomyoma" of the uterus.

I have never found these cysts in women after the menopause and some of those which I have studied were small and apparently retrogressing rapidly. In two instances in which I found adhesions with adenoma of endometrial type in the pelvis, but no gross evidence of

these cysts in the ovaries, pockets were found in the periphery of the ovaries lined by columnar cells and a cellular stroma resembling endometrial tissue. I interpreted these pockets as the possible remains of a perforating hemorrhagic cyst in which nearly complete retrogression had occurred. For these reasons I have concluded that their life may sometimes be of short duration, and the "characteristic" adhesions resulting from them may persist long after the cyst has disappeared.

The adhesions form equally as interesting a pathologic study as the cysts themselves because adenoma of endometrial type is present in the tissues involved by the adhesions in a large percentage of the cases. I have studied histologically the tissues involved by the adhesions outside the ovary in fourteen of the twenty-three specimens, and adenoma of endometrial type was found in thirteen of these.

Some time, or possibly many times, in the life of these hematomas, material, including epithelial tissue and blood ("menstrual"), may escape into the peritoneal cavity from the hemorrhagic cyst or from the "endometrial" pockets in the ovary about the site of perforation and, lodging in the natural pockets and peritoneal folds of the pelvis, they may cause adhesions. Adenoma of endometrial type often develops between the adherent folds of peritoneum thus resulting. *These adenomas may be small, and quiescent or they may be invasive. If invasive they may cause "adenomyoma" of the uterus by invasion of the uterine wall from "without" or "adenomyoma" of the uterosacral ligament, round ligament, rectovaginal septum, rectum, sigmoid, etc., namely, whatever structure or organ is invaded by the adenoma arising from the "infective" contents of the cyst or ovary lodging on its surface.* The question naturally arises, In what way do the contents of the cyst or ovary cause the development of these adenomas? Is it due to some "specific" irritant present in the cyst contents which stimulates the peritoneal "endothelium"; thus causing a metaplasia and the development of "endometrial" tissue typical both in structure and in function? Some may assert that dormant "endometrial" epithelium may be present in the tissues soiled by the contents of the cyst and this is stimulated to further growth. *It seems to me that the condition found in many of these specimens is analogous to the implantation of ovarian papilloma or cancer on the peritoneat surface of the pelvis from the rupture of an ovarian tumor containing these growths.*

I offer the following data as evidence that perforating hemorrhagic cysts of the ovary are hematomas of endometrial type.

1. These hematomas, as the uterine mucosa, manifest their "activity" during the menstrual life of the patient.

2. Histologically, the epithelial lining of the ovarian hematomas is similar to that of the uterine hematomas, due to the retention of "menstrual" blood, often present in "adenomyoma" of the uterus.

3. Periodic hemorrhages occur in the ovarian hematomas which are similar in gross and histologic appearance to that of menstruating endometrium.

4. The "chocolate" contents of the ovarian hematomas resemble old menstrual blood.

5. In two patients operated on at the time of the menstrual period, one the day that menstruation was due (Case 13, Fig. 29), and the other the last day of menstruation (Case 19, Fig. 57), the histologic changes in the ovarian "endometrial" tissue corresponded to the phase of the menstrual cycle indicated by the menstrual history of the patient.

6. The fact that material escaping from the ovarian hematomas may give rise to the development of adenoma of endometrial type in the tissues thus soiled is further proof that these hematomas contain "endometrial" tissue.

I cannot state that these ovarian hematomas of endometrial type are the only cause of ectopic pelvic adenomas.

Perforating hemorrhagic cysts of the ovary with their secondary peritoneal "implantations" are a pathologic entity as definite as that of ovarian papilloma and cancer. They are likewise a definite clinical entity which is capable of diagnosis before operation in a large percentage of the cases.

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# IS PAGET'S DISEASE OF THE NIPPLE PRIMARY OR SECONDARY TO CANCER OF THE UNDERLYING BREAST?

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When Sir James Paget wrote, in 1874, his classical account of the disease which bears his name, he described the condition clinically, rather than pathologically. Based on his own observation of fifteen cases, he outlined the course of a moist, red eczema followed by ulceration of the nipple and areola, upon which cancer of the underlying breast constantly developed. In each of his fifteen cases the breast cancer made its appearance within a year, or at most two years, after the onset of the nipple eczema.

The fact that Paget's description did not include that of the histopathology of the disease has been responsible for much of the confusion which has existed, and still exists, in the minds of surgeons and pathologists over the exact nature of Paget's disease. Without the evidence of microscopic study, it is impossible, many times, to distinguish between true Paget's disease and secondary ulceration of the skin over an advancing cancer. Exactly this mistake has been made by no less an authority than Handley,[1] in a recent communication. Many surgeons consider Paget's disease to be any scabbing or eczema or ulceration of the nipple which follows the clinical course described by Paget. In a well known laboratory, it is considered that "there is no such thing—it either is, or it is not, cancer." And in still a third laboratory, squamous-cell cancer of the nipple is classified with Paget's disease.

## ESSENTIAL FEATURES

It will make for accuracy in discussion of the subject to limit the term "Paget's disease" to conditions presenting the striking, unique and constant histopathology first described by Butlin[2] and Thin,[3] and later confirmed by many others. There are three essential features:

(*a*) *Epidermal Hypertrophy.*—The skin epithelium in the affected area (before the stage of ulceration, and ahead of the advancing margin, after ulceration begins) is increased to two or three times its normal

1. Handley: Brit. J. Surg. **7**:183, 1919.
2. Butlin: Med. Chir. Tr., London **9**:107, 1876.
3. Thin: Tr. Path. Soc., London **32**:218, 1881.

thickness. The papillary bodies not only extend deeper, but are thicker, encroaching from the side on the connective tissue papillae to such an extent as finally almost to obliterate them. These changes are very sharply marked off from the normal epithelium at the edge of the lesion.

(*b*) *Subepidermal Round-Cell Infiltration.*—A very constant feature is a marked infiltration of the connective tissue under the epidermis with lymphocytes, plasma cells and occasional polymorphonuclear leukocytes. The infiltration is usually sharply limited to the affected area and is responsible for the sensation, obtained by palpation, as of a coin buried beneath the epidermis.

(*c*) *The So-Called "Paget's Cells."*—These are large edematous cells in the epithelium, which become vacuolated, with shrunken, pyknotic nuclei, giving the appearance of punched-out holes in the epithelium. They appear first typically in the middle layers of the epithelium and extend downward and upward. Often nearly the whole papillary body is occupied by these cells.

These Paget's cells have been the subject of much dispute. They are, of course, strictly speaking, not Paget's cells at all, inasmuch as Paget made no histologic description; but, since they form a striking and characteristic feature of the disease known by his name, they are commonly called Paget's cells.

## VARIOUS THEORIES

They have been considered, first, to harbor a specific parasite, the cause of the disease; then to be simply degenerated epithelial cells; and, finally, by some authors, to be single-cell metastases of cancer. The earlier parasitic theory has been discarded with later careful microscopic studies under higher magnification. The theory that Paget's cells are actually cancer cells was advanced by Jacobaeus,[4] who believed he had found a direct connection between them and the cells of underlying breast cancer. This work has not been adequately confirmed, while von Winiwarter[5] and others have traced much more convincingly all stages between the prickle cells of the epithelium and Paget's cells. They do not resemble either morphologically or in behavior the cells of cancer arising either in the skin or in the breast gland, and the best opinion is that they are degenerated skin cells.

These, or similar cells, are not found exclusively in Paget's disease, though they are unusual except in this condition. We have found, for example, a group of cells morphologically identical with Paget's

4. Jacobaeus: Virchows Arch. f. Path. Anat. **178**:124, 1904.
5. Von Winiwarter: Arch. f. Dermat. u. Syph. **85**:239, 1907.

cells in the epithelium near the edge of a squamous-cell cancer of the lip, though the other typical features of Paget's disease were lacking.

Furthermore, it is very easy to mistake for Paget's cells actual cancer cells invading the epidermis from an approaching cancer. The appearance in cross-section of a strand of cancer cells invading the skin epithelium from below suggests very strongly the vacuolated, edematous appearance of a true Paget's cell. Sekiguchi [6] has obviously fallen into such error in interpreting some of his cases—an error against which the student should be easily warned by an observation of the frequency of just such appearances when cancer approaches the skin, often associated with the usual subepidermal cell infiltration seen in the various

Fig. 1.—Earliest case of Paget's disease. Process limited to small areas of surface epithelium: *A*, nests of Paget's cells in hypertrophied epithelium; *B*, sharply limited zone of subepidermal-cell infiltration.

stages of ulceration over cancer, and with the well known epithelial hypertrophy also common in this process.[7] Sekiguchi is the most recent representative of the school holding that Paget's disease is itself malignant, drawing from his study the conclusion that "Paget's disease is primary carcinoma of the orifices of the lactiferous ducts or (in extramammary regions) the sudoriferous ducts." This view, we believe, is

6. Sekiguchi: Ann. Surg. **65**:175, 1917.
7. Kilgore: J. Cancer Res. **5**:291 (July) 1920.

untenable. It has often been pointed out by others that the disease exists clinically for years in other regions of the body, in some cases without ever being associated with cancer of any form, in others being followed by squamous-cell cancer. Furthermore, an unusually early case which we have had opportunity to study (Case 1) shows the typical histopathology of Paget's disease, but as yet absolutely no involvement of the ducts. It seems to us very clearly demonstrated that Paget's disease is not itself a form of cancer, nor are true Paget's cells ever migrated cancer cells.

While, therefore, cells like Paget's cells may occur under other conditions, the specific combination of epithelial hypertrophy, subepithelial round-cell infiltration and Paget's cells is so striking and so constant as to call for definite recognition; and it will remove much of the uncertainty which still exists in our knowledge of the condition to limit the term "Paget's disease" to lesions presenting this typical pathologic condition.

### RELATION OF PAGET'S DISEASE TO CANCER OF THE BREAST

Is Paget's disease primary or secondary to the cancer of the breast which so constantly accompanies it?

Paget's original conception was that the eczema of the nipple precedes and is undoubtedly in some way responsible for the later development of cancer in the underlying breast. Since his time, authors have been, for the most part, sharply divided into two schools, one represented by Jacobaeus,[4] who agrees with Paget; the other, represented by Schambacher,[8] who asserts that the breast cancer is always present before the development of the Paget's disease, explaining the existence of the nipple condition for a long period before the cancer becomes apparent, on the well known possibility of a slow-growing scirrhous cancer remaining small for years and hence overlooked.

A consideration of well known facts makes the latter view untenable. While Paget's disease may sometimes be secondary to the cancer, events cannot always follow this sequence, for two reasons: First, typical Paget's disease occurs in regions remote from the breast and never associated with malignant disease of any kind (the illustration showing the pathology of the condition in Ewing's [9] text is taken from a case occurring on the buttock). Second, cases of true Paget's disease, clinically and pathologically, have been found in the nipple and areola over a breast containing absolutely no evidence of cancer. Such cases will be reported later in this paper.

8. Schambacher: Deutsch. Ztschr. f. Chir. **80**:332, 1905.

9. Ewing: Neoplastic Diseases, Philadelphia, W. B. Saunders Company, 1919, p. 808.

It is much more difficult to prove that Paget's disease may sometimes be secondary to breast cancer. Certainly this sequence is unusual, for the skin involvement over an advancing breast cancer usually presents a histologic picture entirely different from that of Paget's disease. But in a histologic study of 500 breast cancers which I made,[7] one case showed the typical pathologic condition of Paget's disease with a clinical history suggesting that the cancer had long antedated the nipple condition (Case 4).

I feel sure, therefore, from a careful study of the cases to be reported here, that Paget's disease, while usually primary, may also be secondary to cancer. The principal reason for the disagreement which has existed over this point lies undoubtedly in the rarity of the

Fig. 2.—More advanced stage of surface condition: *A*, nests of Paget's cells in hypertrophied epithelium. Note the widening of the down-growing epithelial processes obliterating the connective tissue papillary bodies. *B*, zone of round-cell infiltration.

condition, most of the important contributions since Paget's time having been based on studies of one or two cases.

Through the courtesy of Dr. Joseph C. Bloodgood, it has been my privilege to study the material in the surgical pathology laboratory of the Johns Hopkins Hospital. The following case reports comprise all the undoubted cases of true Paget's disease found in a total of more than 1,500 cases of mammary disease (four cases, representing less than one third of 1 per cent. of pathologic conditions of the breast).

CASE 1 (Path. No. 24410).—*History.*—A woman, white, aged 35, who had two children, aged 10 and 7, and in whom there had been no abnormality of lactation, gave a history of slight moisture and scabbing of the left nipple for eighteen months.

*Operation.*—Complete breast and axilla operation was performed by Dr. W. A. Fisher.

Gross Specimen: This shows over about half of the nipple a smoothness and thickening of the epidermis which is also seen on section. Palpation gives a definite sensation of induration under this area. The change, however, is very slight.

Microscopic Examination: This area shows the typical histology of early Paget's disease with epithelial hypertrophy, Paget's cells and subepithelial round-cell infiltration (Fig. 1). Careful search through the gross specimen fails to reveal any evidence of tumor of any kind—only a few dilated ducts in the nipple zone. Microscopic search through blocks cut from various areas of the breast shows only these dilated ducts with some desquamated cells, but with nothing to suggest the picture of duct adenocarcinoma of the type usually seen with Paget's disease. Axillary lymph nodes show only endothelial hyperplasia.

*Comment.*—This is a case clinically and pathologically typical of Paget's disease—certainly in one of the earliest stages in which the condition has been observed. A thorough search through the breast failed to reveal any sign of gross or microscopic malignancy, either in the form of definite tumor, epithelial invasion of connective tissue, or hyperplasia of the duct epithelium. The conclusion is necessary therefore that in this instance Paget's disease occurred before the development of cancer in the breast.

CASE 2 (Path. No. 21819).—*History.*—A woman, white, single, aged 74, had had crusting of both nipples as long as she could remember—little warty crusts which would slowly form and then drop off, being renewed usually about once a year. A year ago she struck the left nipple with her hand, and it bled for a few days, so much that she wore a cloth over it. A crust then formed as usual but had been growing larger for four or five months, and the nipple had disappeared, leaving in the center of its former site the crust surrounded by an elevated zone, red and eczematous, which the patient had first noticed five months ago.

*Operation.*—Complete excision of the left breast with a zone of skin was made. There was no axillary dissection.

*Examination.*—Gross Specimen (Specimen sent by Dr. A. F. Robinson): On section through the nipple, the red area is seen to be very superficial with no gross cancer beneath. In the position of the nipple there is a circumscribed area about the size of the end of the little finger which gives one the impression of a depressed nipple, and beneath this a fan-shaped zone of breast stroma mixed with fat. There are no dilated ducts, no cysts, and no gross evidence of tumor.

Microscopic Findings: There is no evidence of cancer in the stroma. The ducts deep in the breast, however, are plugged with proliferated cells, the morphology and staining reactions of which suggest the cells of duct cancer. The characteristic changes of Paget's disease are found in the epithelium of the areola (Fig. 2). In this instance, it was not possible to trace continuously the changes from the nipple to the deeper ducts mentioned above, though it is probable that if sections had originally been taken with this in view, such continuous changes could have been traced.

*Result.*—The patient was well two years after operation; the condition of the opposite nipple being unchanged.

*Comment.*—This case, like Case 1, is typical Paget's disease, clinically and pathologically, and yet no definite tumor existed in the breast, and not enough change in the deep duct epithelium was observed to make a positive diagnosis of malignancy. It must be considered, therefore, another case in evidence that Paget's disease occurs primary to, or at least before the development of, mammary cancer.

Case 2 represents the second step in the development of cancer in the underlying breast from Paget's disease, as the process has been con-

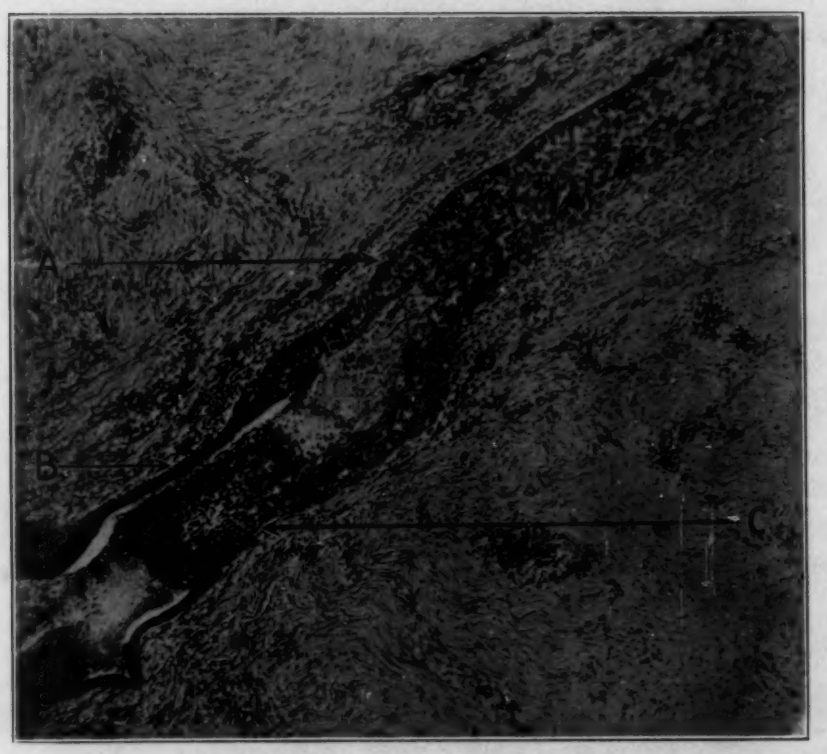


Fig. 3.—Transition in a duct between the extending disease *A* and normal duct wall *B*. At *C*, the duct curves a little so that its roof was cut in the section, obscuring the transition point on one side.

ceived by Duhring and Wile [10] and others. According to this view, the skin condition appears first (as in Case 1). The process then extends from the skin into the ducts in its second stage (Case 2), and finally, by excessive proliferation deep in the breast, the cells burst out of the ducts, invading the connective tissue and forming cancer.

10. Duhring and Wile: Am J. M. Sc. **88**:141, 1884.

This conception is probably not far from the truth. Certainly the process can be shown to extend from the Paget's disease at the surface, down progressively along the ducts (Case 4), and it resembles in many ways the process at the surface. More than one observer has been able to see the point at which the proliferated cells plugging the ducts apparently break through the duct wall and invade the connective tissue (Jopson and Speese).[11] It seems unlikely, however, that a change to malignancy on the part of the epithelial cells occurs on account of over-filling of the ducts and rupture of their walls, but rather that the latter occur on account of malignant properties already developed in the cells. We have, as yet, no good explanation of when or how the change from benignancy to malignancy occurs, unless it be at the moment when the proliferative process in the ducts begins at their orifices, and that this process is from its inception a duct adenocarcinoma.

Case 2 presents clinically interesting points in the long duration of the condition of scabbing of both nipples, and the development of Paget's disease in one after trauma.

CASE 3 (Path. No. 21065).—*History.*—A woman, white, aged 72, single, had eight months before examination, first noticed itching around one nipple with some surrounding redness which gradually spread. There had been some mucous discharge from the nipple. A scab formed over the nipple and gradually replaced it.

*Examination.*—This scab with the areola around it was redder than normal and when this reddened area was picked up, it was felt to be distinctly infiltrated. No nodule could be felt in the breast.

*Operation.*—The breast was excised; axillary dissection was not performed.

Gross Pathology: The nipple was replaced by a scabbed ulcer with a surrounding zone of redness. On section, the epithelium in this zone was visibly thickened and there was definite induration under it. No tumor was found in the breast—only a few dilated ducts.

Microscopic Findings: The nipple changes presented the typical histology of Paget's disease, while the dilated ducts seen in the gross specimen presented microscopically the picture seen in the ducts of duct cancer (such as those in Case 2); but in this case also they were isolated and formed no definite tumor (Fig. 4).

*Comment.*—In this case again, true Paget's disease of the nipple had antedated any definite tumor in the breast, and the reasonable presumption is that it had antedated the early changes seen in the ducts. The process is similar in its stage of development to that observed in Case 2.

CASE 4 (Path. No. 22629).—*History.*—A widow, colored, aged 43; who had had six children—the youngest child being 7 years old, and two miscarriages, had two years before, received a bruise in the upper, outer quadrant of the left breast. Six months later she first noticed a lump at the site of injury. Three months ago, that is, fifteen months after she first noticed the lump, it broke through the skin spontaneously. She had noticed gradually increasing retraction of the nipple for several months and, one month ago, for the first time, she noticed ulceration at the nipple.

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11. Jopson and Speese: Ann. Surg. **62**:212, 1915.

*Operation.*—A complete operation for cancer was performed.

Gross Specimen: This shows the nipple replaced by an ulcer, and the areola at the site of the nipple retracted. On section, the ulcerated cancer in the upper outer quadrant is at least 4 cm. from the nipple, but extending from the nipple in the direction of the tumor are seen dilated ducts filled with yellowish material. The suggestion in the gross specimen is that the nipple ulceration has been caused by the discharge of irritating material from these ducts.

Microscopic Findings: The epithelium at the margin of the nipple ulcer shows the typical pathologic condition of Paget's disease, and the mouth of one duct is found plugged with proliferated cells resembling those of duct cancer. The plug of cells extends down the duct 2 or 3 mm. and ends in an abrupt

Fig. 4.—Process as it appears when it has extended to the deep ducts of the breast. The ducts are plugged with cells and present an appearance similar to that of duct cancer: *A*, vacuolated cells, resembling Paget's cells; *B*, zone of round-cell infiltration.

transition to apparently normal duct epithelium (Fig. 3). No other plugged ducts are found either in the nipple section or in blocks taken between this area and the tumor.

*Comment.*—In this case the tumor had been present at least fourteen months and had ulcerated through the overlying skin two months before the nipple ulceration was noticed. Either this was faulty observation on the part of the patient, or the cancer was present before the Paget's disease of the nipple. I do not believe the patient's observation was faulty for three reasons: (1) Her attention had been called to the nipple by its retraction, and ulceration would

undoubtedly have been observed. (2) Experience shows that patients are quick to observe changes in the nipple. In a study of 500 breast cancers which I have made, no nipple epithelial change was found pathologically which had not been observed by the patient as eczema or ulceration. (3) The pathologic condition of this specimen itself suggests that the Paget's disease is recent, for the characteristic proliferative changes in the ducts have progressed only 1 or 2 mm. below the nipple epithelium.

I believe that the obvious inference is correct, namely, that the Paget's disease followed on a primary breast cancer, but I am not justified in making a positive commitment on the evidence of one case. My justification in thus reporting and discussing a single case presenting this sequence of cancer first, and Paget's disease second, rests on the rarity of the condition, but four instances of true Paget's disease having been found among 1,100 breast cancers observed during twenty-five years.

### OTHER NIPPLE ULCERS

Ulceration of the nipple may be the first sign by which a deeper cancer manifests itself, a cancer which may not be found as a palpable tumor for months or years after the nipple change begins. The cancer may be so deep in the breast that excision of the nipple and surrounding zone of breast and skin would fail to include any of the cancer and so lead to erroneous diagnosis. This is illustrated by the case herewith reported:

Case 5 (Path. No. 7107, not true Paget's disease).—*History.*—A woman, white, aged 55, married, with four children, the youngest 27, had had cracked nipples during her lactations years before. Eight months before examination the left nipple had shown slight erosion and had scabbed over, the scab falling off every few weeks. No tumor was felt in the breast. The record contained no description of the condition of the areola around the nipple.

*Operation.*—Excision of the nipple and zone of breast and skin was made.

Microscopic Examination: This showed only chronic and acute inflammation. No cancer was found.

*Result.*—Three years later this patient was operated on for an infiltrating cancer near the scar in the breast, and died one month later from cerebral metastases. There is no good reason to doubt that the cancer already existed at the time of the first operation, was the cause, and not the result, of the nipple condition, and would have been found on pathologic examination had the entire breast been removed.

*Comment.*—A case almost identical in its history with Case 5 has been reported by Martin,[12] in which a woman, aged 61, presented crusted nipples for one year. The nipple was excised and pathologic examination revealed only simple inflammatory changes, which were mistakenly diagnosed "Paget's disease." Two years later, the patient returned. Examination revealed a hard, irregular mass beneath the scar in the breast. It proved to be scirrhous cancer which had already metastasized to the axilla.

It seems to me that the lesson in Case 5 and of Martin's case is perfectly clear, namely, that any persistent eczema or ulceration of the nipple, whether

12. Martin: Ann. Surg. **64**:725, 1916.

true Paget's disease or not, requires, for the patient's safety, excision of the entire breast, not of the nipple alone.

SUMMARY

1. From the point of view of intensive study of the condition, the term "Paget's disease" should be limited to those lesions presenting the typical histology: (*a*) epithelial hypertrophy; (*b*) subepithelial round-cell infiltration; (*c*) Paget's cells.

2. All the cases of Paget's disease reported, however, as well as Case 5 and Martin's case (not true Paget's disease), emphasize the importance of removing the entire breast for any chronic, persisting nipple eczema or ulcer, regardless of the apparent presence or absence clinically of deeper breast changes. At operation, the decision for or against axillary dissection should depend, not on frozen section diagnosis of the nipple condition between true Paget's and other eczemas, but on the pathologic condition of the breast itself. The best procedure is amputation of the breast with a wide zone of skin, using the knife cautery in cutting across the lymphatics leading to the axilla, and proceeding immediately to the axillary dissection if any gross or frozen section evidence of cancer be found in the excised breast.

3. Three cases are reported demonstrating that Paget's disease is usually primary to cancer of the breast which has been found constantly in association with it. In one of these cases no change whatever had as yet occurred in the breast, and in two cases the early changes of what was probably duct carcinoma had begun when the breast was excised. A fourth case is reported in which all the evidence of history and pathology points to a reversal of this order, the cancer in the breast apparently originated first, and was followed by Paget's disease of the nipple. If the deductions in this case are correct then both schools in the controversy over the primary or secondary nature of Paget's disease have been right, since either order of events may occur.

4. Three stages in the process by which we believe cancer in the underlying breast develops from Paget's disease are illustrated by the various cases reported. Figure 1 shows the condition, limited to the surface; Figure 3 shows the condition in course of extension down the ducts from the nipple [13] while Figure 4 is from a case in which the process had extended to the deep ducts. The picture resembles closely that of duct cancer. The final stage in which the cells plugging these deep lying ducts break out into the connective tissue and give rise to

13. Figure 3 is from the case in which deep cancer preceded the Paget's disease, but it is obvious that, once started, the Paget's disease is behaving as it usually does, extending down the ducts from the surface.

scirrhous cancer was not found in this series but has been observed by other authors.[11]

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NOTE.—A very complete bibliography of the literature of Paget's disease may be found in Deaver and McFarland: The Breast: Its Anomalies, Diseases and Their Treatment, Philadelphia, P. Blakiston's Son & Co., 1916, p. 696. Since the publication of this bibliography, the following articles have appeared in addition to those already referred to:

Fowler: Tumors of the Areola and Nipple of the Breast, Med. Times **45**:195, 1917.

Burns: Paget's Disease and Carcinoma, Edinburgh M. J. **17**:161, 1916.

Potter: Extramammary Paget's Disease, Jour. Cutan. Dis. incl. Syph. **34**:306, 1916.

Harett: Case of Paget's Disease Treated by Radiotherapy, Jour. de radiol. et d'électrol., Par. **3**:416, 1918-19.

Trimble: Eczema of the Nipples, Arch. Dermat. and Syph. **13**:253, 1920.

Hartmann: Maladie de Paget, Rev. gén. de clin. et de thérap. **31**: 581, 1917.

Thorndike: Dermatitis Simulating Paget's Disease, Boston M. and S. J. **77**:122, 1917.

Brunsgaard: A case of Paget's Disease, For. med. Selsk. i Kristiania, 1916, p. 149.

# SQUAMOUS-CELL CARCINOMA OF THE URINARY BLADDER

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Various investigators have shown that columnar and transitional epithelial linings in certain organs of the body are capable of extensive epidermization when a protective covering is desirable. Broders [1] has found a transition from a columnar to a squamous covering in everted, prolapsed irritated uteri. Rokitansky [2] describes a stage of epidermoid metaplasia of the mucous membrane of the urinary bladder as cholesteatoma. Kretschmer [3] collected from the literature the reports of forty-four cases of leukoplakia of the bladder, ureter, and pelvis of the kidney, showing that the urinary tract, normally lined by transitional epithelium, is capable of developing a squamous-cell surface. The traumatized exposed surfaces of extrophied bladders practically always show areas of epidermization.

Hallé [4] holds that this epithelial transformation of the mucosa of the urinary passages results from chronic inflammation, either simple or due to stones. He reports seven such cases in the bladder, in all of which there was cystitis; in four there were stones. Similar cases, associated with calculi, are reported by Cabot,[5] Nogués [6] and Verriére.[7]. Albarran [8] mentions the occurrence of epidermization following long-standing cystitis. Morris [9] describes the conversion, under prolonged irritation, of the lining of a ureter, which for a long time had been the resting place of calculi, to a thick and wrinkled membrane which histologically was divisible into cutis vera and epidermis. While chronic

1. Broders, A. C.: Personal communication.
2. Rokitansky, C.: A Manual of Pathologic Anatomy, Philadelphia, Blanchard and Lea, **1**:306, 1855.
3. Kretschmer, H. L.: Leukoplakia of the Bladder and Ureter, Surg., Gynec. & Obst. **31**:325-339 (Oct.) 1920.
4. Hallé, N.: Leucoplasies et cancroides dans l'appareil urinaire, Ann. d. mal. d. org. génito-urin. **14**:481, 577, 1895.
5. Cabot, A. T.: A Case of Cystitis with the Formation of a Thick Epidermal Sheet in the Bladder, Am. J. M. Sc. **101**:135-142, 1891.
6. Nogués, P.: Trouble des urines du la présence exclusive des cellules epitheliales, Ann. d. mal. d. génito-urin. **17**:585-589, 1899
7. Vierriére, A.: Deux cas de leucoplasie de la muceuse vésicale, Lyon méd. **95**:116-125, 1910.
8. Albarran, J.: Les tumeurs de la vessie, Paris, Steinheil, 1892.
9. Morris, H.: Surgical Diseases of the Kidney and Ureter, London, Cassell, **2**: 1901.

irritation is a common cause of the condition, it is not an essential factor in all cases. Leber [10] reports the case of an infant of 4 months in whom the epithelial lining of the pelvis of the kidney was composed of many layers of cells showing cornification; a similar condition was found in the infant's eye. This case suggests a congenital origin. Lecène [11] holds that the process in these cases is due, not to chronic inflammation, but to developmental changes in the genito-urinary tract. Wilson [12] suggests that epidermoid growths of the pelvis of the kidney may be due to inclusions of ectodermal cells carried from the rectum to the kidney by way of the cloacal wall. Malignant transformation of this epidermized epithelium is not an uncommon event. According to Ewing,[13] squamous metaplasia which affects the cells before the tumor develops accounts for the presence of epidermoid carcinoma in unusual

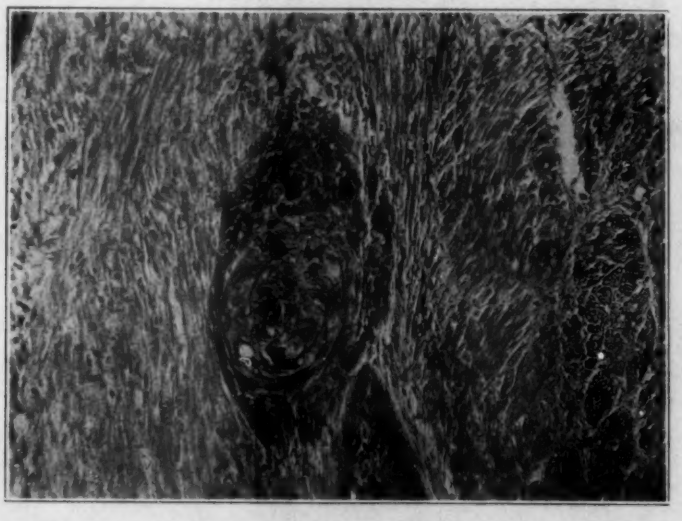

Fig. 1 (Case 2, 147667).—Isolated malignant focus with epithelial pearl growing between muscle bundles in the vesical wall; × 100.

situations. Typical squamous-cell carcinoma, which has all the characteristics of this disease on the cutaneous surface, is occasionally found in the genito-urinary tract.

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10. Leber, T.: Ueber die Xerosis der Bindehaut und die infantile Hornhautverschwärung nebst Bemerkungen über die Entstehung des Xerophthalmus (Abstract), Deutsch. med. Wchnschr. **10**:206, 1884.

11. Lecène, P.: Un cas de leucoplasie du bassinet, J. d'urol. méd. et chir. **1**:129-137, 1913.

12. Wilson, L. B.: The Embryogenetic Relationships of Tumors of the Kidney, Suprarenal, and Testicle, Ann. Surg. **57**:522-535, 1913.

13. Ewing, J.: Neoplastic Diseases, a Textbook on Tumors, Philadelphia, W. B. Saunders Company, 1919.

Albarran [14] notes that vesical leukoplakia may become transformed into true epidermoid cancer. Hallé [4] also is of the opinion that these tumors become engrafted on epidermized plaques. Buerger,[15] in describing squamous-cell tumors of the bladder, states that the mucous membrane in the immediate neighborhood often shows leukoplakia. A number of squamous-cell carcinomas of the ureter and of the pelvis of the kidney have been described. Kischensky [16] cites a case of squamous-cell epithelioma of the pelvis of the kidney with extensive metaplastic changes in the surrounding tissues and extending down the ureter into the bladder.

Primrose [17] reported a case of squamous-cell carcinoma of the renal pelvis complicated by a stone in a horse shoe kidney. Scheel [18]

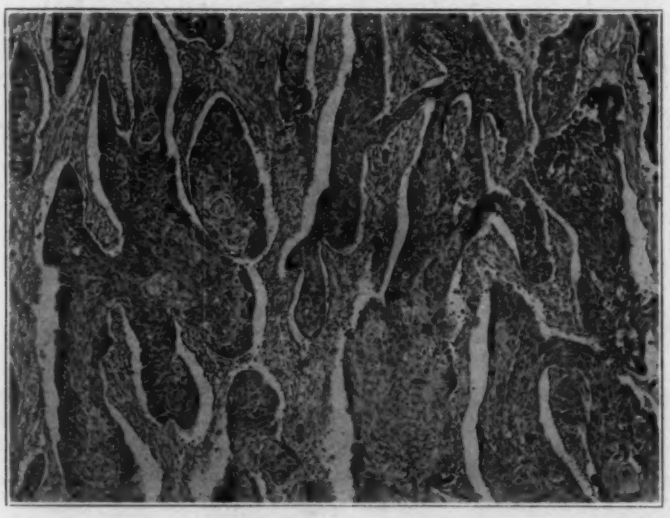

Fig. 2 (Case 3, 203917).—Wide spread extension of tumor masses through the outer layers of the wall of the bladder; × 50.

describes a combination of papilloma and squamous-cell epithelioma of the pelvis of the kidney with multiple metastases. The metastases

14. Albarran, J.: Neoplasmes primitifs du bassinet et de l'uretere, Ann. d. mal. d. org. génito-urin. **18**:918-954, 1900.

15. Buerger, L.: The Pathological Diagnosis of Tumors of the Bladder with Particular Reference to Papilloma and Carcinoma, Surg., Gynec. & Obst. **21**: 179-198, 1915.

16. Kischensky, D. P.: Primärer Plattenepithelkrebs der Nierenkelche und Metaplasie des Epithels der Nierenkelche, des Nierenbeckens und des Ureters, Bietr. z. path. Anat. u. z. allg. Path. **30**:348-369, 1901.

17. Primrose, A.: Squamous-Cell Carcinoma of the Kidney, J. A. M. A. **75**:12 (July 3) 1920.

18. Scheel, P. F.: Ueber ein eigenartiges Kankroid der Niere, Virchows Arch. f. path. Anat. **201**:311-325, 1910.

showed only cells of the squamous type. In 195 tumors of the kidney observed at the Mayo Clinic there was one squamous-cell carcinoma of the pelvis of the kidney. Garceau [19] cites a case of Adlers of epidermoid carcinoma of the ureter. Rundle [20] also describes a very extensive tumor of this type originating in the lower end of the ureter and markedly infiltrating the surrounding tissues and metastasizing to the liver and lungs.

Cases of epidermoid carcinoma of the bladder are not uncommon. Albarran found four cases in a review of 125 cases of vesical tumor. Three of the patients died very shortly after operation; one was well four months later. Hallé collected the reports of a number of cases from the literature and gives the history of four patients observed at

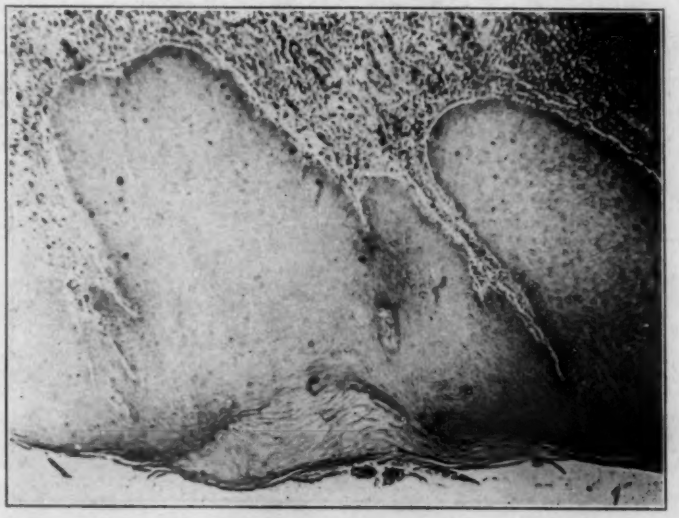

Fig. 3 (Case 3, 203917).—Epidermization of mucosa in regions adjoining squamous-cell carcinoma; × 50.

the Necker hospital. In three of these four patients the condition was inoperable; the patients died shortly after entering the hospital. The fourth patient was operated on and died immediately after the operation. Montfort [21] collected seven cases: in three, there was an extension to the rectum; in a fourth, the growth had spread through the dome of the bladder, a mass "the size of an apple" being found in the

19. Garceau, E.: Tumors of the Kidney, New York, D. Appleton & Co., 1909.

20. Rundle, H.: Epithelioma of the Ureter Causing Hydronephrosis, Tr. Path. Soc., London, **47**:128-132, 1896.

21. Montfort, E.: Rôle de la prostate dans la production des tumeurs epitheliales infiltrées de la vessie, Thèse, Paris, Rousset, 1903.

adherent great omentum. Montfort states that in all his cases the tumor was complicated by marked cystitis. Of 113 neoplasms of the bladder, Buerger [15] regarded five as squamous-cell carcinoma. He states that they rapidly penetrate the muscular coats and that they offer a very poor prognosis for the patient. Fenwick [22] cites two cases, one in which a benign papilloma was surrounded by a dense squamous-cell epithelioma. There was marked infiltration of the wall of the bladder, the vesical surface being flat and necrotic. The second case was that of an extremely large tumor arising from the posterior wall of the bladder and having a history of only six months' duration. Geraghty [23] states that squamous-cell carcinoma is exceedingly rare.

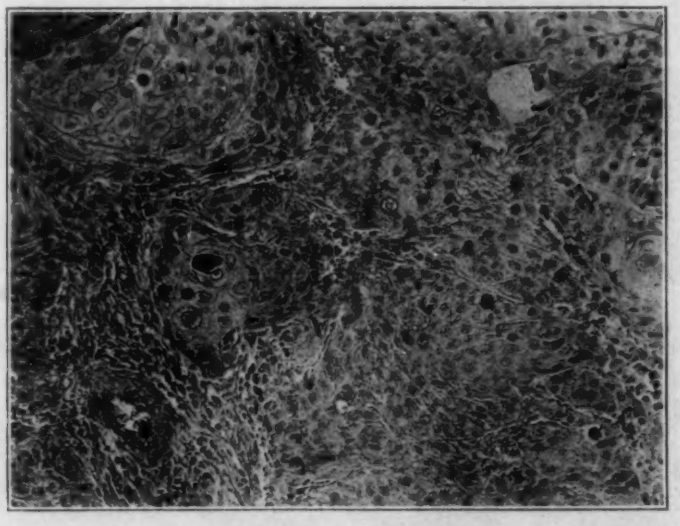

Fig. 4 (Case 3, 203917).—Solid masses of tumor cells with many epithelial pearls. A number of malignant cells show two or even three deeply staining nucleoli; × 100.

He found only one case in 180 epithelial tumors of the bladder observed in Johns Hopkins Hospital. Busse [24] describes a case associated with a papillomatous growth in the ureter and extensive metastases. Cassanello [25] reports two cases, in one of which the his-

22. Fenwick, E. H.: A Handbook of Clinical Electric-Light Cystoscopy, London, Churchill, 1904.

23. Geraghty, J. T.: Quoted by Cabot H.: Modern Urology, in Original Contributions by American Authors, Philadelphia, Lea and Febiger, 1918.

24. Busse, O.: Geschwulstbildung in den grossen Harnwegen, Virchows Arch. f. path. Anat. **164**:119-132, 1901.

25. Cassanello, R.: Contributo allo studio dell' epithelioma epidermoidale della vesica con speciale riguardo all question del chorion epithelioma vesicae, Folia urolog. **3**:509-540, 1909.

tologic structure of the growth greatly resembled a chorio-epithelioma. He states that the growth in his cases was very malignant, rapidly and extensively infiltrating the surrounding tissues.

The majority of squamous-cell carcinomas of the bladder are flat and ulcerated, extensively involving the wall. The preoperative symptoms are generally of short duration. In most cases the symptoms are mild and do not give a correct indication of the extent of the condition. Metastases occur, but not so frequently nor so extensively as the extent and appearance of the local lesion would indicate. Squamous-cell tumors, in general, especially those showing marked differentiation, do not metastasize readily. The metastases in most cases are confined to the local lymph areas. Sanderson [26] has observed a case of squamous-cell epithelioma of the penis, with metastases to the inguinal nodes. Five years later there had been no further metastases.

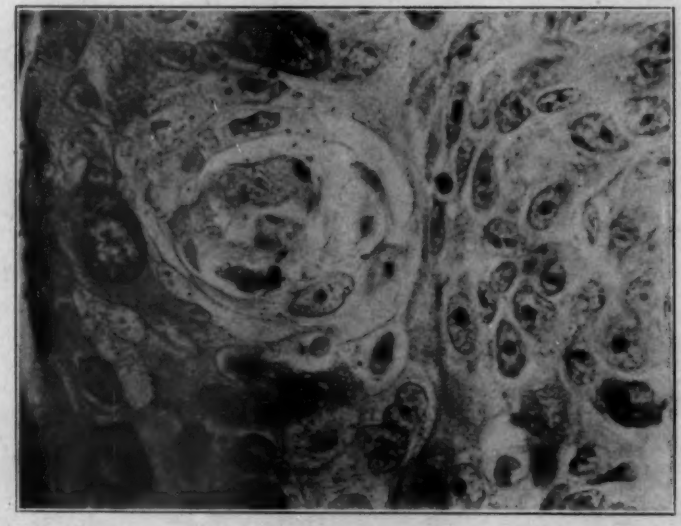

Fig. 5 (Case 3, 203917).—Atypical mitotic figures, irregularity in size and staining qualities of cells and large deeply staining nucleoli, "one-eyed malignant cells" (Broders); × 500.

Mitotic figures are fairly common in epidermoid tumors of the bladder, but they do not always indicate a high degree of malignancy. Broders [1] holds that mitotic figures are not so important a criterion of malignancy in epithelioma as they are in connective tissue tumors. Evans [27] showed that in sarcoma and myosarcoma the malignancy varied directly with the number of mitotic figures. Broders has seen

26. Sanderson, F. R.: Personal communication.

27. Evans, N.: Malignant Myomata and Related Tumors of the Uterus, Surg., Gynec. & Obst. **30**:225-239 (March) 1920.

patients with epithelioma of the penis with numerous mitotic figures alive and well three years after operation in contrast to other patients in whom mitotic figures were rare who died shortly after operation from recurrence of tumor.

Six cases of squamous-cell epithelioma in 333 neoplasms of the bladder were observed in the Mayo Clinic from Jan. 1, 1910, to Jan. 1, 1920. These six cases are of interest not only because of their extreme malignancy, but because of the insidious onset and the lack of definite symptoms. The growths are readily recognized histologically, and this is of distinct prognostic importance.

CASE 1 (60036).—Mrs. M. P., aged 45, came to the clinic, Oct. 13, 1911, because of frequent attacks of hematuria during the last four months. She had not had pain but had lost 30 pounds in weight in the four months.

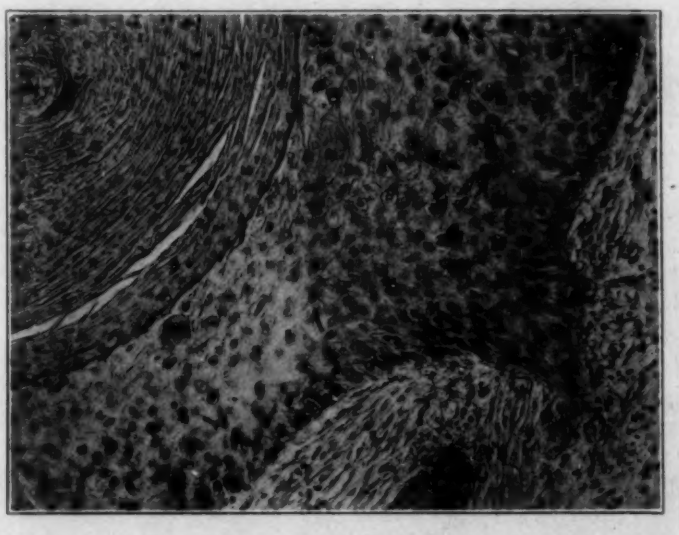

Fig. 6 (Case 5, 313258).—Wide spread hyalinization, showing layered cleavage planes of hornified areas; × 100.

The general physical examination was negative. The cystoscopic examination showed a flat nodular growth 3 cm. in diameter on the upper left wall of the bladder. At operation an indurated broad base carcinoma was found, and a transperitoneal resection of the upper third of the bladder was performed. The patient readily recovered from the operation. She returned to the clinic two years later with a small recurrent growth which was removed by fulguration. Seven years after fulguration and nine years after operation she is well, and has no signs or symptoms of recurrence.

The excised tumor was rough, flat, firm, and friable, 2 cm. by 3 cm., and extended down, out into surrounding submucous tissues. It was covered by keratinized tissue 3 mm. thick. This readily flaked off. Histologic examination revealed a typical squamous-cell carcinoma. It consisted of branching columns and large solid masses of only moderately differentiated epithelial cells. The

cells, in the main, were large, irregular, pale and unevenly stained, with prominent nucleoli. In the larger masses the peripheral cells were smaller and more deeply stained. The central or older cells showed degenerative changes and in some areas were arranged in circular whorls of completely hyalinized cells—the so-called epithelial pearls. A few areas showed a tendency toward papillomatous formation, the cells arranging themselves around a connective tissue axis and assuming a palisade formation. Large masses and strands of malignant cells projected into the submucous and muscular tissue and at times isolated epithelial pearls were seen pressed between muscular and fibrous bands. There was a marked round-cell infiltration, mostly plasma cells, not only throughout the malignant area but also in the submucous and muscular coats of the bladder. A large number of mitotic figures, the lack of cellular differentiation, and the irregularity and varying size of the cells, with the local extension, indicated a high degree of malignancy.

Case 2 (147668).—Mrs. W. B., aged 54, was examined in the clinic, Dec. 10, 1915. She had been troubled with frequency of micturition and periodic

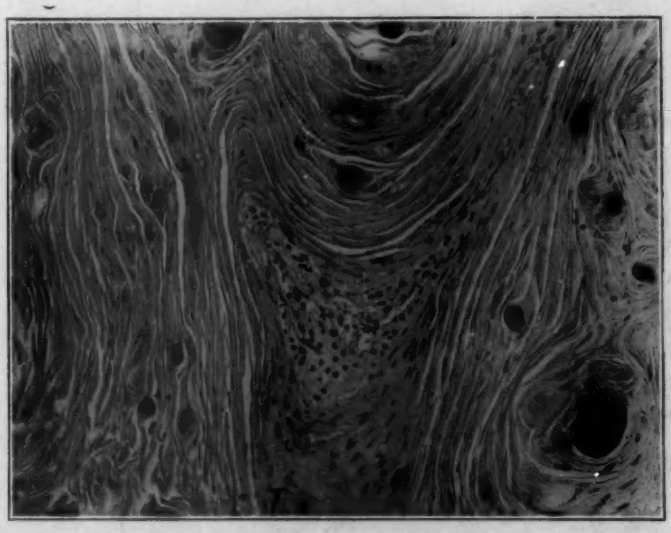

Fig. 7 (Case 5, 332791).—Extreme hyalinization of tumor masses; × 100.

irritability for twenty-eight years. The urinary trouble started directly after a difficult childbirth. Twenty-four years before examination she had had several attacks of severe pain in her right loin; the last one had occurred twenty years before. For the last three years, frequency and dysuria had been slight and infrequent. Two months before there had been a marked exacerbation of the urinary trouble and a slight terminal hematuria. The recent bladder trouble was more severe and "different" from that of the last twenty-eight years.

On physical examination, a hard, tender mass 4 cm. in diameter was felt in the suprapubic region. Cystoscopy revealed a flat growth 6 cm. in diameter on the right half and dome of the bladder. At operation an extensive indurated tumor was found extending from the dome to the right base. A transperitoneal extirpation of the right half of the bladder was performed and the right ureter ligated. The patient convalesced satisfactorily. Four months later, a small recurrence of the tumor was fulgurated. After two months, the recurrence

persisting, the bladder was reopened and three small growths cauterized. Six months later, one year after the first operation, the patient died from recurrence.

The tumor was 5 cm. in diameter; its surface was ulcerated. It involved the entire wall of the bladder, and in one area it extended to the peritoneum. In places the growth was fibrous and dry with a tendency to split along cleavage planes, as is often seen in papillary carcinomas. Microscopic examination revealed in certain areas a high degree of differentiation with extensive hyalinization and pearly body formation (Fig. 1). In other areas the cells were large, irregular, and active with no tendency toward epidermization. There were many mitotic figures and a moderate round-cell infiltration.

Case 3 (203917).—Mr. W. A. P., aged 32, came to the clinic, Aug. 4, 1917, because of pain in the lower right abdomen, and moderate frequency and dysuria of three months' duration. During this time he had lost 20 pounds in weight. Cystoscopy revealed a necrotic mass 6 cm. in diameter on the dome of the bladder. At operation a large carcinoma of the dome and posterior wall was discovered. The mucosa of the remainder of the wall of the bladder

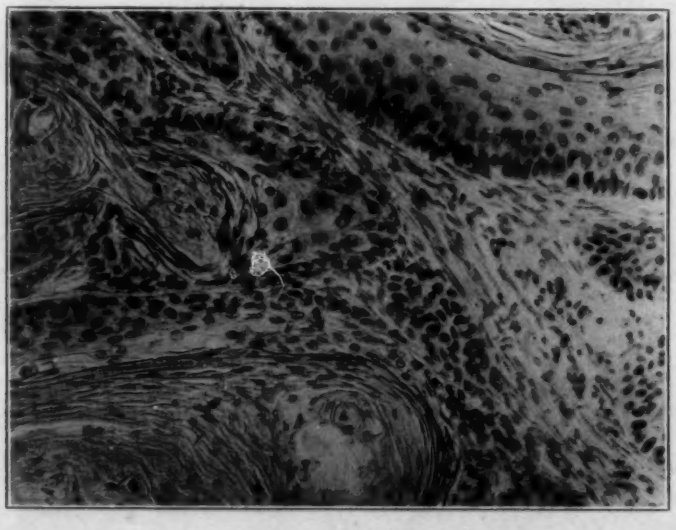

Fig. 8 (Case 6, 332791).—Extensive pearly body formation with many rapidly growing malignant cells; × 100.

was moderately necrotic. A transperitoneal resection of the upper third of the bladder was performed. The patient recovered normally, but died six months later from extensive local recurrence.

The tumor was flat and firm with an ulcerated necrotic surface 6 cm. in diameter. The sides sloped outward to meet the mucosa of the bladder, the infiltration extending deeply into the muscular coats. In one section the neighboring mucosa was covered by an area of leukoplakia. The histologic examination revealed marked round-cell infiltration. The cells were only slightly differentiated, although only moderate pearly body formation was seen. The individual cells were partly hyalinized in a few areas and retained their rounded contours, large nuclei, and prominent nucleoli. There was marked connective tissue reaction; in some sections this completely isolated parts of the tumor (Figs. 2, 3, 4 and 5).

CASE 4 (305220).—Mrs. S. R. P., aged 31, was examined in the clinic, Feb. 4, 1920. Eleven months before, while pregnant, she had had moderate hematuria for one week. Three months later she was delivered of a normal baby. Ten days later she passed a small amount of gravel with severe pain. She was cystoscoped by her home physician who told her that she had a papilloma of the bladder. He fulgurated the growth nine times in six months. Pain over the lumbar region with swelling of the left thigh and leg appeared three months before examination. The pain had been very severe and hematuria marked during the last week.

Physical examination revealed discrete, firm, movable, enlarged glands above the clavicle, in the left iliac region, and in the abdominal fat. A mass 2 cm. by 6 cm. was felt through the vagina in the region of the bladder. On cystoscopic examination a flat necrotic mass was found spread over the left base, left ureteral orifice, and anterior wall of the bladder. The metastases and local condition obviously made the growth inoperable. The patient rapidly became weaker and died five months later.

Examination of a specimen removed during the cystoscopic examination revealed squamous-cell carcinoma of a high degree of malignancy. The cells were large and irregular with active nuclei. There was practically no differentiation, the cells showing only a slight tendency toward cornification and circular disposition.

CASE 5 (313258).—Mrs. G. D. K., aged 47, was examined in the clinic, April 21, 1920. She had been troubled with slight incontinence, which started following childbirth twenty-nine years before. Two unsuccessful attempts had been made to repair her urethra, one eighteen years before, the other four years before. She had not had hematuria or dysuria, but during the last year incontinence had increased with some frequency.

On examination a lacerated perineum and urine dripping from the urethra were found. A firm, fixed mass 10 cm. in diameter was palpated in the region of the bladder. Cystoscopy revealed a tumor involving the entire bladder except the anterior wall. An exploratory operation was performed, and 720 mg. hours of radium given. The bladder and surrounding tissues were extensively involved in the growth. The patient did not recover her strength after the operation and died four months later.

The specimen removed was gray, firm, and compact. It was markedly fibrous throughout. Areas of complete differentiation alternated with sections of malignant tumor cells. In the latter areas the cells were large, well formed and packed closely, projecting in finger-like masses into the surrounding tissue. In some areas hyaline and cystic degeneration of individual cells was found (Fig. 6). Areas of round cells were quite numerous.

CASE 6 (332791).—Mr. W. C., aged 67, came to the clinic, Sept. 6, 1920. He complained of weakness and loss of weight of one year's duration. He had lost 90 pounds, mainly during the last three months, and had had dysuria, frequency, and moderate difficulty in micturition. For three weeks he had complained of a sense of discomfort over the pubes.

The prostate was found to be enlarged, irregular, firm, and tender. The roentgenograms contained a shadow in the region of the bladder 5 cm. by 6 cm. An exploratory operation was performed and a rough, flinty stone corresponding to the shadow was removed. The entire wall of the bladder was covered with a soft, grayish tumor. Large masses of the growth were scooped out and the bladder closed loosely around a tube. The patient died two days later. At necropsy, bilateral obstruction of the ureter was found. On the left side was

a pyonephrotic kidney with multiple abscesses, and on the right pyonephrosis with atrophy of the kidney. The wall of the bladder was infiltrated with a grayish tumor; on the posterior superior wall was a diverticulum 4 cm. in diameter. A stone 2 cm. by 5 cm. was found in the prostatic urethra.

Histologic examination of the growth revealed almost complete cellular differentiation; the tumor was a mass of hyalinized tissue. The cornification had taken place in long bands and multiple large rouleaux with only scattered areas of flattened tumor cells. Throughout the cornified areas were many small deposits of calcareous degeneration. Cleavage lines were easily seen, especially in areas where the formation was separated during the preparation of the specimen (Figs. 7 and 8).

## COMMENT

Three of the six patients were seen in an operable condition an average of three months after the first appearance of symptoms. One of these had a recurrence four months after operation, and died eight months later; one died six months after operation, and one, the only patient who did not die from the disease, is living and well nine years after operation. The other three patients had inoperable tumors. In the inoperable cases, there had been symptoms referable to the carcinoma for an average of twelve months.

Two of the six patients had histories of urinary trouble with undoubted cystitis for more than twenty-eight years. This corresponds to the preoperative history of patients with leukoplakia and may represent such a preexisting condition, the aggravation or exacerbation of symptoms indicating the onset of malignancy. In only one patient (Case 6) was the tumor complicated by stone formation. The extreme hyalinization pointed to a long-standing condition, possibly a simple epidermization, even though the period of symptoms had been short. It is remarkable that with such an extensive local growth there were no metastases. This is probably due to the low incidence of metastasis from tumors of such a high degree of cellular differentiation.

The average age of the patients was 46 years, strikingly lower than the general average age of patients with carcinoma of the bladder. The incidence of sex, four women and two men, is also exceptional and contrary to the usual occurrence in which the male outnumbers the female three or four to one.

Case 1 indicates that a permanent cure is possible. The tumor in this case was highly malignant. An early resection was successful in spite of the local extension and the extreme malignancy of the tumor.

In most cases the insidious onset and the rapidity of the growth make squamous-cell tumor of the bladder an exceptionally dangerous disease.

SUMMARY

1. Under certain conditions, such as trauma and infection, the mucosa lining the urinary tract undergoes extensive epidermization.

2. These areas of metaplasia, or, as they are termed, leukoplakia, have a predisposition to form squamous-cell carcinomas of a very high degree of malignancy.

3. Six cases of squamous-cell carcinoma of the bladder are reported; five of the patients died shortly after the disease was discovered.

# CANCER OF THE BREAST*

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OMAHA

In a former contribution, I reported 166 cases of mammary carcinoma in which operation was performed by radical methods, with one immediate death from postoperative pneumonia. Letters were sent out to the 165 surviving patients, or members of their families, and 101 replies were received. Of the 101 answers received sixty-three stated that the patient had been free from the disease for periods of from three to twenty-one years. Of the remaining thirty-eight patients, two were living but were suffering from recurrence, and thirty-six were found to have died of local or disseminated cancer. Four of these were not considered by their relatives to have died of cancer, but from the descriptions of the symptoms, death was obviously due to cancer, and was so considered.

Today, I am able to add twenty-four more cases, in which questionnaires were recently sent. Answers have been received from twenty-one patients. Twelve are reported to be in good health, and apparently without a return of the disease. Nine are reported dead. The sister of one of these reports the death as from tuberculosis; but it is fair to infer that it was pulmonary carcinoma, and I feel justified in counting it as a death from cancer. Still another died of influenzal pneumonia only a few weeks after I had operated on her for an extensive local recurrence, with a very grave prognosis. Though pneumonia was the immediate cause of death, the postoperative condition was so grave that it seems only fair to count this among the unsuccessful cases, so it is included on that side of the ledger. Of the remaining seven deaths, the lesions in six cases were very extensive at the time of operation, two of them having adhesions both to skin and to pectoral fascia; and all showing extreme involvement of the axillary glands. Of the nine fatal cases, seven were considered at the time of operation very bad risks.

Combining the last twenty-four with the 166 previously reported, we have 190 cases for consideration. Of these it has been possible to trace only 122; sixty-eight I have not been able to get replies from. Of the 122 cases traced, seventy-five were free from recurrence for from three to twenty-one years, and forty-seven were reported as having died or as suffering from a hopeless recurrence. Computing the

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*Read in the cancer symposium at the Clinical Congress of Nebraska Surgeons, March 3, 1921.

results only on the 122 cases heard from would show 62 per cent. well from three to twenty-one years after the operation. This is manifestly too high. Computing the results on the 190 cases in which operation was performed would show 39.5 per cent. well for from three to twenty-one years. This is too low. The truth apparently lies somewhere between these figures.

No one any longer reports his cancer patients as cured. A three-year limit or a five-year limit is purely arbitrary. It is conceded that each year elapsing after a radical operation, without a return of the disease, makes recurrence less likely.

I have had patients remain apparently well for five, eight, nine or ten years, and then report with a recurrence from which they soon died.

The length of time the existence of the lump has been known and the apparent extent of the disease at the time of operation are not nearly such good indexes of the prognosis as one would, theoretically, suppose. The discovery of the lump is usually accidental, bearing no definite relationship to the date of the beginning of the disease, or to the extent of its dissemination. Some of the patients with apparently extensive mammary and axillary involvement have been free from recurrence for many years, and *per contra* several patients with only a small lump in the breast, recently discovered, with no apparent extension to the axillary or other glands, have died of early and rapid recurrence. There are degrees of malignancy. The two cases herewith reported are illustrative of the fact that it is not easy to formulate a prognosis in advance.

### REPORT OF ILLUSTRATIVE CASES

CASE 1.—Mrs. B., aged 46, had first noticed a lump in her right breast only six weeks before I saw her. In this short time ulceration of the skin had already begun, and there was extensive axillary involvement, which was only partly cancerous, it being largely inflammatory. An extensive radical operation was performed, Sept. 3, 1917. Five months later she returned with no local recurrence on the side operated on, but with extensive cancerous disease of the opposite (left) breast. Radical operation was performed on the left side, Feb. 13, 1918, and the left axillary glands were found invaded. She is reported to have died of extensive recurrence over the entire thorax, Oct. 28, 1918, about fifteen months after she first discovered the small lump in her right breast.

Case 2 is another case that shows the opposite tendency.

CASE 2.—Mrs. R. presented a very extensive involvement of the left breast with massive infiltration of the axillary glands. It was so bad I hesitated about operating, considering the prognosis absolutely grave. The operation was performed Jan. 15, 1918. Dr. C. C. Green, of Beaver City, Neb., reported her well and free from recurrence Jan. 30, 1921.

### DEGREES OF MALIGNANCY

Why one breast cancer is so virulent and another so mild we do not know. There is no doubt that the cell energy in one case is so great it beats down all defenses that the normal tissue cells are capable of building up, while in another the attack is less overwhelming and the tissue defense is able to hold the growth in abeyance for a long time. In some patients the defense is feeble, scarcely any fibrous tissue being formed, and the lawless cells proliferate almost at will. In other cases the fibrotic enveloping movement is so prompt and effective that the cancer cells have a very precarious time. It is possible that, under favorable conditions, they may be smothered and a cure of the carcinoma may take place without any one suspecting that it ever existed. At the opening of the battle, there is no means of knowing how forcible is the attack or how adequate the defense; therefore an accurate prognosis is impossible.

I want again to emphasize that a local recurrence should not be considered the sounding of the death knell. Several of my patients have been operated on for a first, a second, and even a third recurrence, and are still alive and apparently free from disease up to ten years after the last recurrence. In order to give the patient the best chance, an operation for recurrence must be carried out along the same lines and with the same boldness as the original operation. Every operation for recurrence, as well as every primary operation, is followed by intensive roentgen-ray treatment.

### ADVANTAGES OF EARLY OPERATION

The clinical picture of breast cancer presented in textbooks needs to be revamped. Even now conscientious physicians who have patients come to them with a lump in the breast calmly wait to see whether malignant symptoms will develop. When one can make a positive preoperative diagnosis of cancer, it is too late for the best average results. The ideal operation for mammary carcinoma is the one that starts in as an exploratory incision. The frozen section made at once by a competent pathologist, together with an intelligent macroscopic examination of the growth after it has been removed, is coming to be the chief method of making the diagnosis.

The praiseworthy efforts to educate the general public and, incidentally, the medical profession as a whole, about the early symptoms of cancer, are bearing fruit, thus far sparingly; but the wonderful possibilities when this propaganda is really carried across make one look forward to the time when the cancer problem will be solved, or at least will cease to be the awful thing it now is.

If any woman could be kept under sufficiently close observation she could be assured against death from cancer of the breast. I should like

to see tried the experiment of keeping 1,000 women under the observation of a trained clinician for a series of years, in order to see whether the above statement cannot be made good. And, if proved true, why could it not be extended to 100,000 women or to all the women of cancer age in the United States? It could be applied equally well to cancer of the uterus, and of the lip, and, in a less positive degree, to cancer of the internal organs.

This idealistic machine is not yet in working form. For the present we can act only when cases come to our attention. A lump in the breast should be looked upon as an emergency surgical condition. In most of these cases it is impossible to say positively that the growth is benign. If cancer is already present, the cell division, the infiltration of tissue, the growth along the lymphatics cannot be expected to mark time, while a slow-thinking and slow-acting physician is looking wise and waiting for symptoms to develop that will permit him to make a positive diagnosis.

### ORIGIN OF MAMMARY CARCINOMAS

All pathologists are agreed that many mammary carcinomas originate in chronic cystic mastitis; but there seems some question as to whether they originate in adenomas. MacCallum in his "Textbook of Pathology" says: "In such cases it seems necessary to conclude that the carcinoma has developed from an adenoma, but there is no more difficulty in this assumption than in the more usual one that it develops from the normal epithelium of the gland." The favorite site of adenoma is in the upper outer quadrant. Forty-four per cent. of the carcinomas appear in the upper outer quadrant. Most adenomas cause enough neighborhood irritation to produce a surrounding zone of chronic mastitis. It seems safe to conclude that the most usual precancerous lesions recognizable in the breast are benign tumors and chronic cystic mastitis. Therefore, the removal of all benign breast tumors, and the amputation of breasts that are the seat of chronic cystic mastitis, will prevent the development of carcinoma. How great a number of cancers could be prevented by systematically following this plan is not known, but it would no doubt reduce the incidence of breast cancer by a considerable percentage.

### PATHS OF DISSEMINATION

Before one should be considered qualified to operate for breast cancer, he should have a good understanding of the paths by which it disseminates. The antiquated procedure of slashing off the breast and ineffectively clearing the axilla of fat and glands is fast being relegated to history.

Extension in breast cancer, except the very local infiltration of adjacent tissue, is chiefly through the lymphatics, and metastases through the blood vessels play a minor rôle, usually occurring after all hope of a successful operation is past. Ewing in "Neoplastic Diseases" states that in mammary carcinoma the part played by the blood vessels is distinctly less than that of the lymphatics. We are indebted to Handley for pointing out clearly the rôle of the lymphatics in the dissemination of cancer. Pathologists and clinicians alike are more and more accepting his ideas.

Following the line of reasoning laid down by Handley, if the chief route of dissemination is embolic, through the blood stream, we would expect the locations of metastasis to be similar to the locations of embolic infections, such as are seen in pyemia. This is far from the fact. In pyemia the frequency of splenic and of hepatic abscess is as two to three; in breast cancer the frequency of splenic and of hepatic secondary involvement is as one to fourteen. Again the distribution of secondary deposits is very different in cancer of the uterus, stomach and breast, but it always varies according to the location of the primary growth. In cancer the extension seems to radiate in all directions, but most rapidly in the direction in which the lymphatic supply is richest.

For a long time it was supposed that extension along the lymphatics was accomplished by the cells being swept along the lymph current; but it has been found that the growth extends almost as freely against the current as with it. This bears out Handley's contention that the cancer cells grow along the lymphatic channels by direct growth or permeation. Conceding the general correctness of extension by permeation, it is important to study how the dissemination occurs from a primary nodule located in the breast.

The most important lymphatic highway leads from the breast to the axillary glands. This is especially true in the upper outer quadrant, in which almost one half of all breast cancers originate. Invasion of the axillary glands is usually the first point of attack outside the breast and the pectoral fascia, and they are involved in most cases sooner or later. Occasionally, however, the lungs, the liver and other organs are invaded first, and, in rare instances, the patient may die without the axillary glands having been involved.

Underneath the median hemisphere of the breast is a chain of lymphatics leading to the subclavian glands. These glands should never be overlooked.

The cancer cells may reach the mediastinum, the lungs or the pleura, by growing along the lymphatics that accompany the perforating branches of the internal mammary artery. Averaging the statistics of

several observers, as quoted by Ewing, about 50 per cent. of late cancer cases show invasion of the thoracic cavity.

It is not infrequent for the cells to grow along the lymphatics to the front of the sternum, and to pass along the anastomosing branches, reaching the opposite breast or opposite axillary glands. In my own series, I have records of eight patients that returned later with cancer of the opposite breast. Handley finds the invasion of the opposite breast in 7 per cent. of his cases, and Williams observed it at necropsy in ten of forty-four cases.

Another favorite route of extension is downward to the epigastric angle where the abdominal wall is penetrated, and invasion of the peritoneal cavity begun. It is only an inch, on the average, from the lower lobule of the breast to the epigastric angle. The fascial linea alba is very easily invaded by cancer cells. They pass through to the falciform ligament, fastening themselves on the upper convex surface of the liver; or some of them may pass down by gravity to the lower abdominal cavity, invading the ovaries or uterus. In 2,534 cases of breast cancer reported by a number of hospitals, invasion was found in the liver in 928, or 36.6 per cent.

## OPERATION

Having a clear idea of the lines along which cancer is disseminated, a definite form of operation calculated to cut off all these highways of dissemination, as far away as possible from the primary growth, appeals to one as the natural procedure. If all the radiating lymphatic trunks can be blocked off, well outside the zone of actual invasion, and all the cancer-bearing tissue within this blocked out area removed, there seems a high degree of probability that the disease will be completely removed.

Before beginning a description of the operation, I wish to speak of a danger that is constantly present in work of this kind. Many local recurrences are unquestionably due to accidental implantation of cancer cells during the progress of the operation. If, inadvertently, the knife enters tissue that looks the least suspicious, the knife and other instruments that might possibly have been soiled, and the gloves worn by operator and assistants, should be pronounced unclean and discarded for new. The suspicious tissue should be swabbed with phenol, and a new and more remote periphery selected. In most cases it is possible to maintain the dissection so far, radially, from the primary lesion that no tissue is entered that looks or feels malignant. It is usually only in advanced cases that any trouble should be encountered.

A routine skin incision is never made. It should be planned according to the location of the growth. A circular or wide elliptical incision is first carried around the primary growth. The margin of this incision should be 2 or 3 inches removed from the infiltrated area. The skin

incision at the upper and outer part should extend from the upper arm at the insertion of the pectoralis and, sweeping inward and downward in a curve just above the axilla, should meet the circular incision at the most advantageous point. The lower leg of the skin incision should extend from the lower margin of the first circular incision, downward and inward to a point 2 or 3 inches below the ensiform over the linea alba.

The old idea that a vast area of skin should be removed had its origin in the mistaken opinion that the cancer extended mainly along the skin. It is now known that the chief mode of extension is along the fascial planes and that the skin involvement means the growing up through the lymphatics from the fascia to the skin. This knowledge has effected a great change in the operation. All skin that seems the least suspicious is removed, but the main object of the operation is to get rid of the lymphatic-bearing fascia over an extensive area, and for a long distance from the primary neoplasm.

The skin is peeled away over this very extensive area first; then the fascia is circumscribed all around by cutting vertically through it at the periphery. This marks out the tissue that it is proposed to remove. The fascia is then rolled inward from the periphery toward the common center. To work from the breast toward the axilla would make it possible to squeeze and push cells growing in the lymphatics toward the axilla, and it would be possible to drive cancer cells from axillary glands into supraclavicular glands. In the same manner, by working downward toward the epigastric angle, cells might be driven into the upper abdomen, gaining lodgment on the liver. Or, by working toward the sternum, cells might be carried into the anterior mediastinum, or even across the anterior surface of the sternum, through the collateral lymphatics into the lymphatics of the opposite side, infecting the opposite breast and axilla. The aim of the operation is to remove all malignant foci, and to do it without risking mechanical extension through ill-advised handling.

Having raised the skin flaps as widely as seems necessary, the attack begins at the axilla. The tendon of the pectoralis major is severed at its attachment, and the muscle is rolled inward, being at the same time separated from the clavicle. After the pectoralis minor is laid bare, this muscle is completely removed. It is never cut and later sutured, as has sometimes been advised. Next, by dividing the costocoracoid membrane just below the clavicle, good access is gained to the axillary space. By care it is easy to get a line of cleavage above the axillary glands and fat, at the superior boundary of the axilla. Gradually the axillary content is worked down by sharp dissection, preferably seeing what is cut and catching any bleeding vessels as the dis-

section proceeds. The dissection should then be carried inward below the clavicle, carefully separating the fat and glands below from the subclavian artery and vein above. By this free exposure, it is easy to see what is done and to make the dissection clean, without risk of damaging vessels or nerves. It is highly important that all the subclavian glands be removed. They are especially liable to be invaded early if the primary neoplasm is located in the inner hemisphere of the breast.

Going back to the axilla, the dissection is carried downward along the lateral surface of the thorax, laying bare the latissimus dorsi and serratus magnus, and dissecting these muscles bare of all glands and fat. I think it is well to sacrifice several of the upper digitations of the serratus magnus as they grow well under the breast and might be involved. They may be removed quite freely, without noticeable impairment of function. If the primary growth is small and localized at the inner segment of the breast, their removal is less imperative than if the growth is advanced, or located in the outer hemisphere.

Passing now to the epigastric angle, the fascia covering the rectus and external oblique is peeled up from below, marking the lowest part of the dissection. This blocks the highway toward the abdomen.

Internally, the skin flap having been raised well toward the midline of the sternum, the fascia is peeled away from within outward, by a clean dissection from the sternum, the costal cartilages and the ribs. This shuts off communication with the opposite breast and the thoracic cavity.

As soon as the entire periphery of the tract to be removed has been raised, it is easy to remove the remainder. By a few strokes of the knife, the entire area marked off can be removed from the chest wall. This is done as cleanly and neatly as possible. Nothing impairs the appearance of this operation so much as to leave tufts of muscle standing out over the thoracic wall; but such an appearance is of minor importance as compared with the possibility of leaving some cell groups which would defeat the object of the operation, or devitalized tissue which may complicate smooth healing.

Hot packs are then placed over the entire denuded area to aid hemostasis. All bleeding vessels have been caught in forceps as the dissection proceeded and now they are methodically tied with fine plain catgut. A stab wound is made through the external skin flap a little below the axilla, and through this is drawn, from within outward, a small rubber drainage tube which is removed in twenty-four hours.

The skin has been undercut over so great an area that its borders are easily approximated without tension. Three to six silkworm-gut sutures are used to bring the skin edges into contact, and a running, interlocked suture of horse hair will quickly and neatly approximate the edges of this long incision.

### POSTOPERATIVE TREATMENT

A copious sterile gauze dressing is put on, and bound on with a jacket. The arm is kept well abducted from the thorax and the elbow rests easily on a pillow. The patient is encouraged to use the arm from the first. No trouble about arm motion has been experienced since it has been kept well away from the side. The second morning after the operation, the patient is propped up in bed, if there is no contra-indication, and after the third or fourth day, she spends a part of each day in an easy chair.

Intensive roentgen-ray treatment is made use of after every radical operation for breast cancer. Everything seems to indicate that this treatment increases the prospects of permanent relief. It doubtless destroys some cells that might otherwise cause trouble.

### INOPERABLE CASES

In spite of all the propaganda, occasional cases are encountered in which it is better not to operate. Among these may be mentioned: (a) deep involvement of the chest wall; (b) firm fixation of the tissues to the chest wall; (c) fixation of the axillary mass; (d) very extensive skin involvement; (e) enlarged and fixed supraclavicular glands; (f) secondary growths in the lungs, liver or other viscera; (g) bone metastasis.

### PROGNOSIS

In the main it seems to me there is a growing optimistic trend in our attitude toward carcinoma of the breast. Even if nothing more is discovered in regard to cancer, the facts now known give an opportunity greatly to lessen the death rate. We have much to hope for from a changed attitude of the public and the rank and file of the profession. The time is coming when late operations will be very rare; when women will be eager for operation on the first discovery of a lump in the breast; when the entire profession will cooperate in getting these unfortunate women to the operating table early; and when surgeons will all be performing radical and efficient operations. It does not seem too optimistic to harbor the hope that a time is coming when 70 or 80 per cent. of these patients may be permanently relieved.

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# OBSERVATIONS BASED ON A STUDY OF INJURIES TO THE ELBOW*

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NEW ORLEANS

At the present time, a lively interest is being manifested in the subject of fractures. This interest is due to several factors, among which may be mentioned the general dissatisfaction which has resulted from the indifferent measures adopted by many surgeons and the indifferent results which have caused economic loss. The desire for improvement is being aided by laws which are demanding an early restoration of function and efficiency. There is a demand for standardization of method and for better results. The Amercian Surgical Association has been instrumental in getting information relative to disability periods, results and similar questions. Prior to their investigation, many surgeons had a sense of self-sufficiency. Following a study of the results in various clinics, individual surgeons are inclined to be more modest, and are therefore showing the interest which they should in newer methods.

Fractures are still being treated by men who have large surgical experience, but who devote little time to the study of this particular field. Fractures are also often treated by men of little experience and training. Fractures are often regarded as a department of minor surgery, which is wrong. How can fractures any longer be considered minor surgery, when such important factors as "carrying angle," limitation of motion at the wrist, coxa vara and loss of weight bearing are dependent on the result of treatment?

Progress results from applying the lessons of personal experience and information gained through a knowledge of the literature of the past and the present. In this way alone can the patient obtain the best result. Errors creep in inadvertently, errors of omission and commission, lack of proper examination, proper history and treatment.

The most common source of error in diagnosis of fracture lies in ignorance of the essentials necessary to make a diagnosis. If not ignorance, let us call it lack of appreciation of fundamentals which should be utilized. For such men, education should be substituted for censure.

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*Owing to lack of space many illustrations were omitted.

Lack of careful examination and hurried work represent another source of error. Such work demands censure of the individuals as well as education.

Those who, as a result of careful histories, interpret the disability from an anatomic basis, and who also bring to their aid for the benefit of the patient the roentgen ray both before and after treatment, arrive most often at a correct diagnosis. To treat fractures satisfactorily, one must be ever mindful of the relative strength of various portions of bone as well as the comparative strength of bone and ligaments when subjected to strain.

It may seem bold to state that eventually we may hope that diagnosis will often be correctly arrived at by a properly taken history and an analysis of the localization of pain and the associated functional dis-

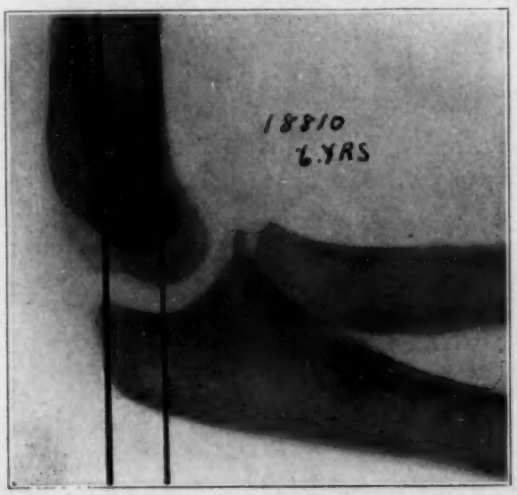


Fig. 1.—Normal relationship of capitellum and great sigmoid cavity. The capitellum occupies the cavity but is not overlapped by the olecranon. The relationship of the lower epiphysis to the bisecting plane of the long axis of the humerus is shown. In early life a plane bisecting the shaft of the humerus passes behind the posterior limit of the capitellum. The plane bisecting the humerus after the ninth year has approximately two thirds of the lower epiphysis in front of it. The plane passed through the anterior limit of the shaft of the humerus has at least one half of the capitellum anterior to it.

ability. When we consider this statement a little more closely, the importance of the truth will be appreciated. Ordinarily, each muscle origin represents the fixed point from which contraction acting on the point of insertion causes the properly coordinated movement. Now, if the bone happens to be fractured between the origin and the insertion of a given group of muscles, this group is rendered inactive.

A lack of harmony results from exaggeration of the action of the opposing group.

Not only is this important in diagnosis; in treatment it is essential to remember it. Otherwise reduction will fail more often than it will succeed.

Any plea for improvement in fracture results must be based not on a preconceived system but on a clearer knowledge and attention to fundamentals.

This report is made because I should like to emphasize the value of fundamental knowledge which should be more widespread and

Fig. 2.—Normal relationship of capitellum and great sigmoid cavity. The capitellum occupies the cavity but is overlapped by the olecranon. The relationship of the lower epiphysis to the bisecting plane of the long axis of the humerus is shown. In early life a plane bisecting the shaft of the humerus passes behind the posterior limit of the capitellum. The plane bisecting the humerus after the ninth year has approximately two thirds of the lower epiphysis in front of it. The plane passed through the anterior limit of the shaft of the humerus has at least one half of the capitellum anterior to it.

the usefulness of which, even among those who should know, we find has not been fully realized. I refer to the roentgen-ray examination particularly of joints and joint fractures in the young. The appearance of the normal epiphysis at varying ages has proved one of the most

fascinating studies I have ever attempted. In another contribution, devoted entirely to the appearance of the normal elbow at all ages up to and including 17 years of age, many interesting facts have been stated.

In the past, we have been impressed by the number of roentgen-ray reports suggesting seriously disturbed elbows, which on clinical examination presented no abnormality, and also by a few cases which suggested a fracture in which the roentgenogram failed to be of service to us. Another type of report which proved puzzling was the number of reported epiphyseal separations.

An analysis of the reported fractures in clinically normal joints can be easily understood after one has made a study of normal joints. The answer is simply that epiphyseal lines were mistaken for fracture lines.

Fig. 3.—A plane at right angles to the base of the capitellum and bisecting it intersects the plane through the middle of the long axis of the shaft at an angle of about 130 degrees (author's lines).

How can we interpret the other two reports? Let us take those in which clinically there is an intra-articular fracture and the report is negative.

We know very well that up to a certain age certain epiphyses are not apparent in the roentgen-ray examination and hence an injury to these will not show on the plate.

It is very easy to see why epiphyseal separations have been reported, because there has not been an available standard for comparison, and further there has not been a general appreciation of the fact that the epiphyses bear a relatively constant position to the shaft.

A diagnosis of epiphyseal separation can be made roentgenographically only by a gross alteration of the normal relationship of the

epiphyses to the shaft, and by certain lines which are here described. If any one has described these lines before, they have not been called to my attention, nor have I seen mention of them in the literature. I believe that, with a clear knowledge of the normal appearance of the elbow, and the relationship of the articular portion of the humerus and the ulna, we can eliminate many errors in diagnosis; and, furthermore, one can definitely state from the roentgenogram that there is an existing deformity. If these things are possible, certainly they need more general adoption, because thereby a source of error will have been corrected.

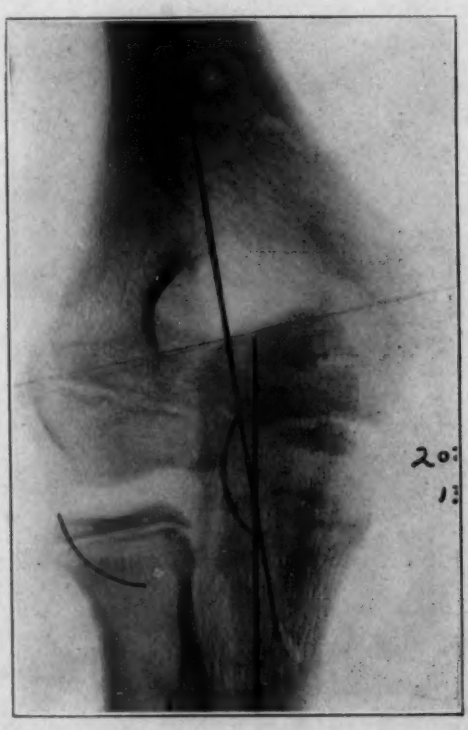

Fig. 4.—With forearm extended and supinated, a plane through the middle of the long axis of the humerus is intersected by a plane through the middle of the long axis of the ulna at an angle of approximately 170 degrees.

The position of the capitellum is most important.

With the elbow flexed to a right angle, a lateral view of the elbow shows the capitellum occupying the sigmoid cavity. In early life, there seems to be a wide separation between the articular surface of the capitellum and the great sigmoid cavity, but with growth the capitellum occupies the entire cavity and is closely approximated to the sigmoid cavity (Figs. 1 and 2).

A plane passed through the middle of the long axis of the shaft of the humerus prior to about the ninth year passes behind the posterior border of the capitellum; after this period the plane bisecting the shaft of the humerus has approximately two thirds of the lower epiphyses anterior to it (Figs. 1 and 2).

The plane of the anterior limit of the shaft of the humerus shows at least one half of the capitellum anterior to it (Fig. 4 and Fig. 1).

A plane at right angles to the base of the capitellum and bisecting it intersects the plane through the middle of the long axis of the shaft at an angle of about 130 degrees (Fig. 3).

Fig. 5.—The normal position of the olecranon, occupying the entire olecranon fossa.

When the forearm is extended on the arm and supinated, a plane passed through the middle of the long axis of the humerus is intersected by a plane through the middle of the long axis of the ulna at an angle of approximately 170 degrees (Fig. 4).

The olecranon occupies the entire olecranon fossa (Fig. 5).

An attempt will be made to show by an illustrative case the value of a knowledge of the exact appearance of normal joints, in order to state definitely from the picture that an epiphyseal separation exists.

CASE 1.—W. B., (20,835), aged 13 years, while playing fell backward and struck his right elbow against a brick curb. He suffered considerable pain.

Examination at the clinic, by Dr. I. M. Gage, revealed considerable swelling over the internal condyle, with pain on palpation. Crepitus was elicited on movement of the elbow. The roentgenogram (Fig. 6*B*) shows the epiphysis of the internal epicondyle widely separated from the shaft and on a much lower level than the internal oblique line of the shaft. The elbow was flexed and bandaged in the usual hyperflexed position. A picture in this position shows a restoration of the normal position of the internal epicondyle to the shaft (Fig. 6*A*).

To illustrate the point that roentgenograms fail us in diagnosis of intra-articular fractures, the following case may be cited briefly.

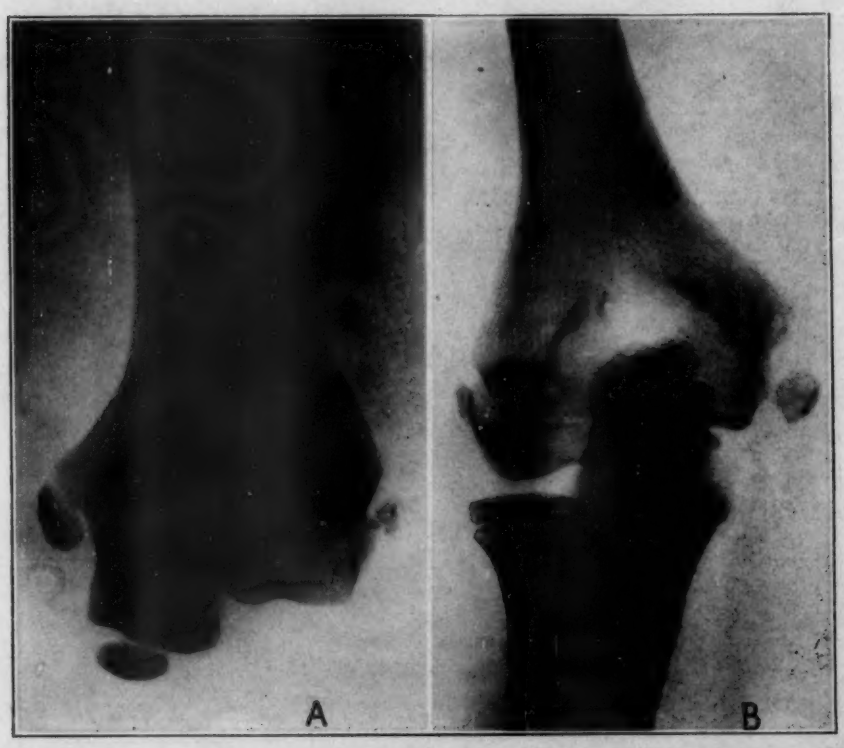


Fig. 6.—*A*, normal position of the internal epicondyle; *B*, position of the internal epicondyle in case of epiphyseal separation, showing the wide separation and illustrating the fact that the epicondyle is on a lower level than the internal oblique line when separated (Case 1).

Case 2.—C. S., boy, aged 8 years, presented the typical deformity of a backward dislocation of the elbow. This is all that was demonstrated by the roentgenogram. Under anesthesia the reduction was easily accomplished, but we were then able to palpate a loose body in the region of the internal epicondyle. The subsequent course was uneventful.

The value of the lines which have been described may best be illustrated by the presentation of a few cases in which the results were not good.

When vicious union has resulted and when the patient presents a cubitus varus, the capitellum does not occupy the sigmoid cavity, but is on a lower level and its shadow is overlapped by that of the olecranon in part (Figs. 7 *A*, 8 *A* and 9 *A*). When a perfect result has been obtained, it is found that the articular surface of the humerus lies in its normal bed.

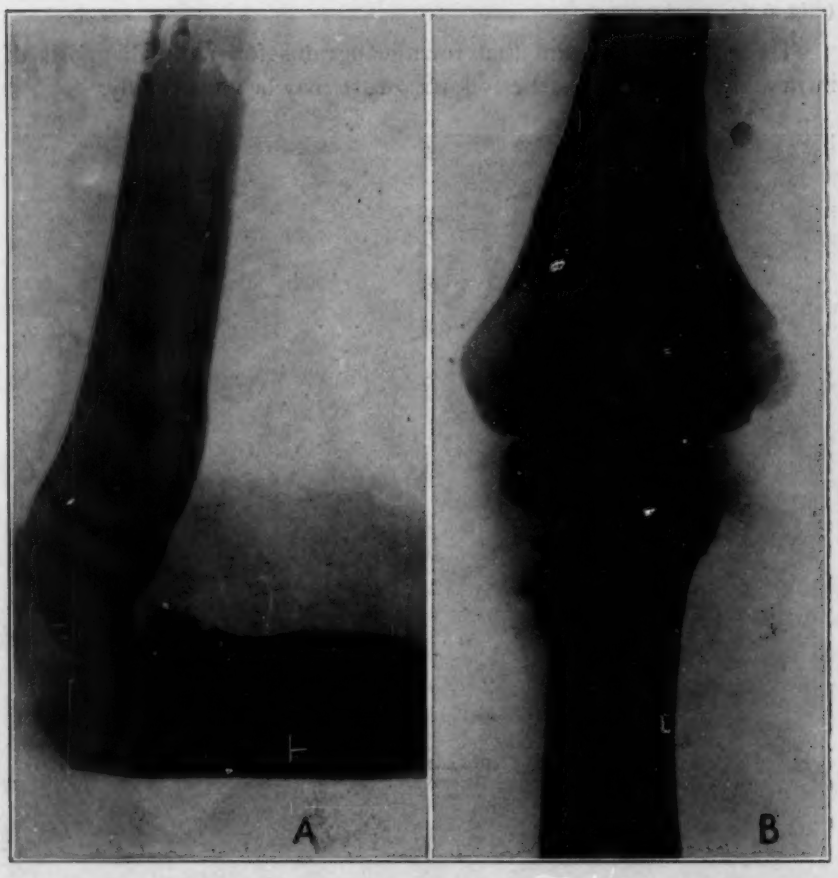


Fig. 7.—*A*, altered position of capitellum when vicious union has resulted, showing overlapping of the capitellum by the olecranon shadow rather than the normal appearance of the capitellum occupying the cavity: *B*, when compared with the normal elbow (Fig. 4), it will be readily seen that the plane through the long axis of the humerus is practically the same plane as the one bisecting the shaft of the ulna, illustrating the value of the lines described in Figure 4.

This report represents an analysis of a group of unselected cases from our clinic and from my private records. An attempt will be made to make the review as impartial as possible.

Several points are apparent.

Many case histories have been incomplete and a considerable number give evidence of hastily taken records of examination. Many reported cases of epiphyseal separation have been received, which are manifestly normal joints in the light of our recent study. Many cases have been referred to the roentgenologist for examination, and negative reports received from that department.

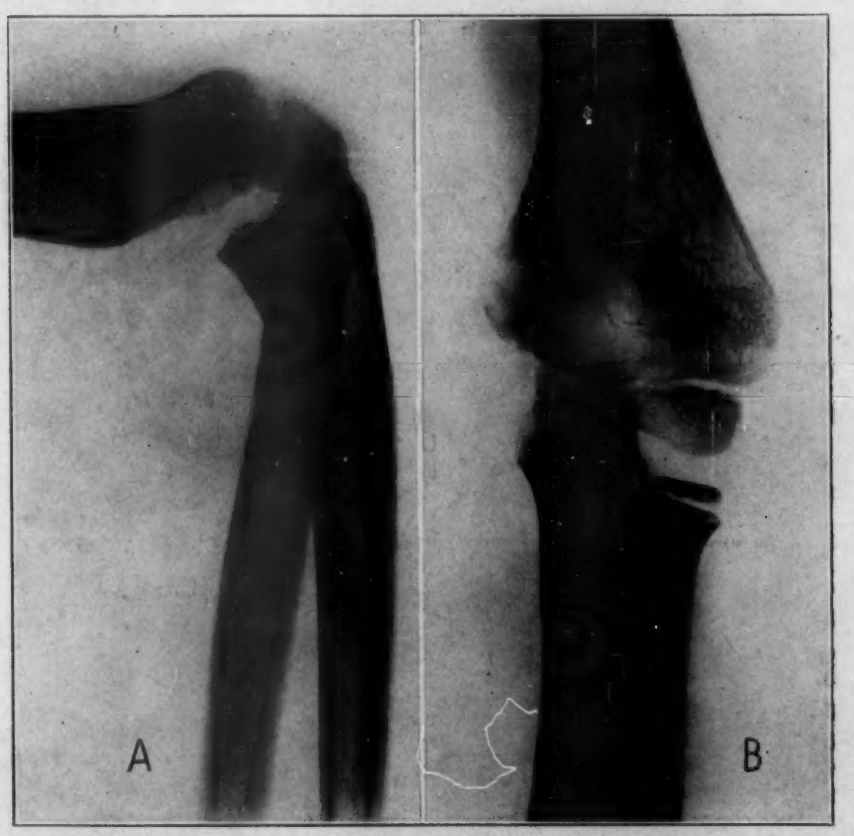


Fig. 8.—*A*, altered position of the capitellum when vicious union has resulted, showing overlapping of the capitellum by the olecranon shadow rather than the normal appearance of the capitellum occupying the cavity: *B*, when compared with the normal elbow (Fig. 4), it will be readily seen that the plane through the long axis of the humerus is practically the same plane as the one bisecting the shaft of the ulna, illustrating the value of the lines described in Figure 4.

These two sources of error suggest three things which are necessary in the treatment of fractures: a clear knowledge of the normal on the part of the roentgenologist; a more careful examination of the patient, to eliminate unnecessary work, and, last, a closer cooperation between the roentgenologist and surgeon which will prove helpful to all.

A suggestion from the roentgenologist that, as a result of his study of the picture, he would make a prognosis of a deformity if the fracture is allowed to remain in the position that it was in when the patient was sent to him, will prevent many future disabilities and deformities.

### DIVISION OF CASES

We may divide the cases of elbow injuries into those in which examinations, clinical and radiologic, have been negative; cases in

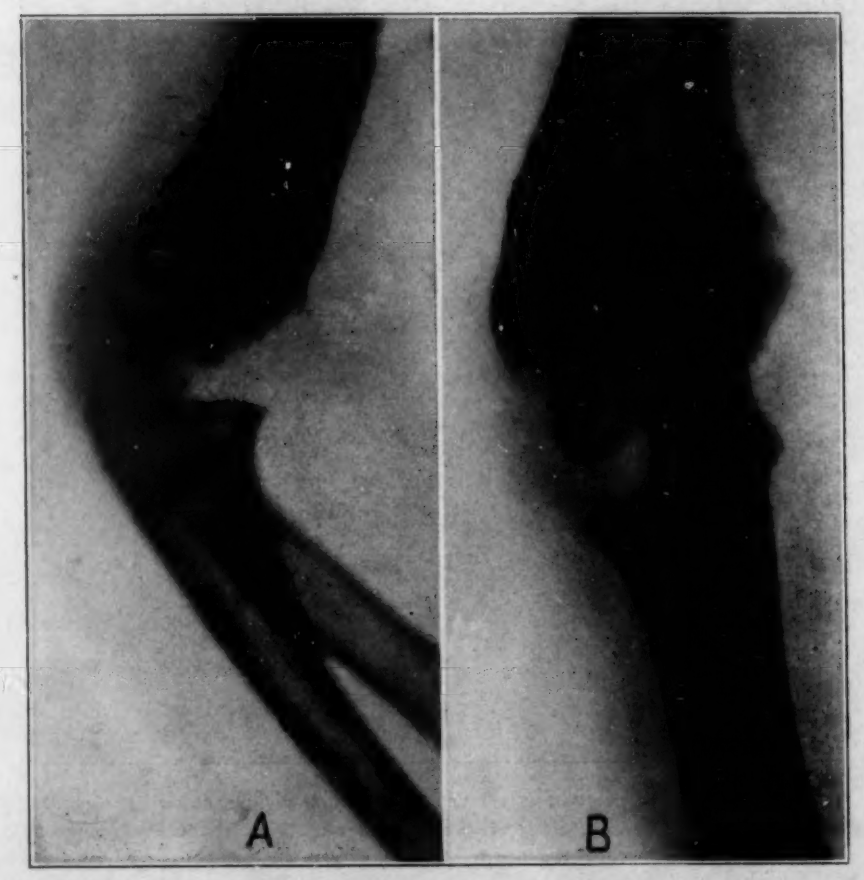


Fig. 9.—*A*, altered position of the capitellum when vicious union has resulted, showing overlapping of the capitellum by the olecranon shadow rather than the normal appearance of the capitellum occupying the cavity: *B*, when compared with the normal elbow (Fig. 4), it will be readily seen that the plane through the long axis of the humerus is practically the same plane as the one bisecting the shaft of the ulna, illustrating the value of the lines described in Figure 4.

which there has been a separation of the epiphyses, and cases in which there has been a fracture. The fracture cases then subdivide them-

selves into two classes; those which come under observation immediately and those which are not seen for several hours.

In an attempt to follow up cases, about seventy-five patients were written to, with a request that they present themselves for examination. From those who returned we have obtained the material for this study. The information thus obtained has enabled us to note whether there was a perfect functional result or how much disability existed, and to

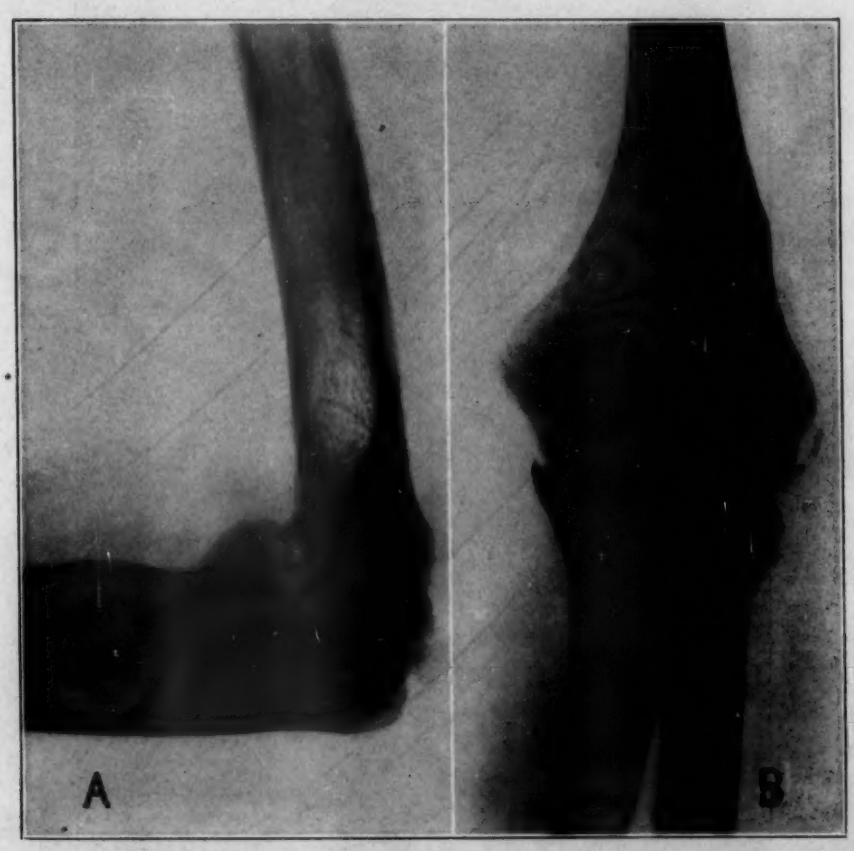


Fig. 10 (Case 7).—Results in a case of supracondyloid fracture which came under observation late.

gather information relative to the roentgen-ray appearance of the fractured bone.

A small group of patients with deformity and disability presented themselves for examination. These cases, while the condition is humiliating, give more real beneficial information than the larger group with good results. It was from the small group which presented disability and deformity that we were made to realize the value of the roentgen ray in making a prognosis.

In every case in which we found an existing deformity, several things became apparent when the history was referred to. In brief, the facts are these: The patient usually presented himself for treatment several hours after the injury, during which time swelling had appeared, making it impossible to maintain the hyperflexed position.

Citation of two cases, with remarks, will serve to prove my point.

Fig. 11 (Case 7).—Results in a case of supracondyloid fracture which came under observation late.

Case 3 (16,790).—I. C., negro boy, aged 4 years, fell from a wagon two days before examination, March 12, 1918.

*Examination.*—The arm hung by his side. There was marked cubitus varus, swelling about the elbow, pain over both condyles, and loss of flexion and extension.

*Treatment.*—Under anesthesia, the impaction was broken up, but we were unable to put the elbow in hyperflexion, as this position caused an obliteration of

the radial pulse. Anterior and posterior plaster splints were applied; the right angle position being used. The roentgen-ray report prior to the dressing was: Supracondyloid fracture, backward displacement of the lower fragment.

*Subsequent Course.*—In following up this case, we found. one year later, that there was a loss of the carrying angle, cubitus varus and limitation of flexion and extension.

April 14, 1919: A cuneiform osteotomy was performed.

Oct. 30, 1920: Examination revealed perfect flexion and extension of the elbow; no limitation of pronation and supination, and a slightly diminished carrying angle.

CASE 4.—G. M. (17,222), June 13, 1918, had fallen from a porch the day before; had been treated in the emergency clinic at Touro infirmary at once with a diagnosis of supracondyloid fracture. No anesthetic was given. The dressing did not include the hand. When I saw the child, the hand and forearm were very much swollen. The hand of the injured arm was much colder than the opposite hand.

*Treatment.*—Under ether anesthesia, an attempt was made to reduce the deformity. It was impossible to utilize the position of hyperflexion, because of

Fig. 12 (Case 7).—Results in a case of supracondyloid fracture which came under observation late.

obliteration of the radial pulse; therefore anterior and posterior molded plaster splints were used.

*Subsequent Course.*—Examination, April 22, 1919, revealed a loss of carrying angle, and slight cubitus varus. The forearm could be flexed to the normal limit and extended completely.

At examination, Nov. 11, 1920, the same notes were made as at the previous examination. The roentgenogram taken, Nov. 11, 1920, revealed: a vicious union of an old fracture of the humerus. The lower portion was united to the shaft in a plane oblique to that of the long axis of the shaft.

The capitellum was overlapped by the shadow of the olecranon and sigmoid cavity, rather than occupying the cavity.

A plane passed through the anterior aspect of the long axis of the humerus passed anterior to the plane of the capitellum, showing that the capitellum was displaced backward.

The plane passed through the middle of the long axis of the shaft was anterior to the capitellum, instead of the capitellum's being either entirely in front of this plane or two thirds of its body anterior to this plane (Figs. 7 *A* and 7 *B*).

CASE 5 (61,920).—L. S., boy, aged 7 years, came under observation in the clinic, May 31, 1919, the day following the accident. Examination made by Dr. P. G. Lacroix revealed: swelling of the forearm, cubitus varus, and pain over the lower end of the humerus. No record was made of the after-care in this case. The child reported to the clinic at my request for examination. I found: marked cubitus varus—slight limitation of flexion; no loss of the normal range of extension, and no limitation of pronation and supination. The roentgenogram in this case presented the same important findings as were noted in the previous case (Figs. 8 *A* and 8 *B*).

CASE 6.—M. S., about five weeks before fell on her outstretched hand. When seen by her local physician, he told the parents that there was so much swelling that he could do nothing for her. Aug. 28, 1920, I examined her and

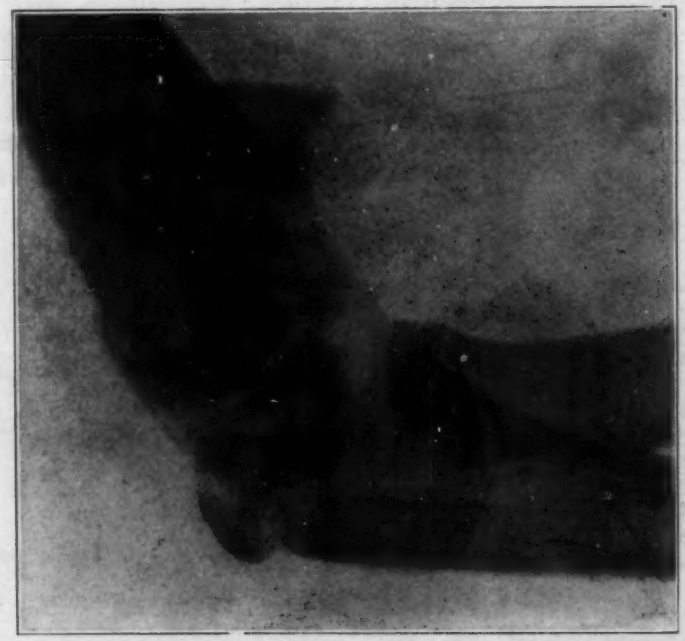

Fig. 13.—Comminuted fracture of the humerus, in which case a fracture of the olecranon was also reported. The apparent fracture is an unossified olecranon epiphysis.

found marked cubitus varus with internal rotation of the arm. There was limitation of flexion and extension of the elbow.

*Diagnosis.*—Vicious union, supracondyloid fracture of the humerus was diagnosed (Figs. 9 *A* and 9 *B*).

*Operation.*—Under ether anesthesia (Dr. Rives, anesthetist), an external lateral incision was made, beginning about the middle third of the arm, and extending down to about the level of the head of the radius. The brachialis anticus muscle was retracted inward, the radial nerve was exposed and retracted inward, as well as the supinator longus muscle. The periosteum was incised and retracted. The brachialis anticus was retracted from the humerus, and an anterior cuneiform osteotomy was performed. The divided ends of the humerus were drilled, and a kangaroo tendon suture was introduced, merely

for temporary fixation. When the elbow was extended, I noticed that the carrying angle had been restored, and complete flexion of the elbow was now possible. A few interrupted sutures were introduced and the arm placed in hyperflexion. The wound healed by primary intention.

*Subsequent Course.*—The patient left the hospital, Sept. 7, 1920, at which time she could extend the elbow well beyond a right angle.

At the time the last note was made on this case, Oct. 30, 1920, the patient could completely extend the elbow. She carried the arm in a position of internal rotation, and pronation of the forearm. If the forearm was supinated and held in this position the carrying angle was restored, showing that there was a relaxation of the external lateral ligament, and that the internal rotators were more active than the external rotators. Roentgenograms (Figs. 9 *A* and 9 *B*) showed the same points as the preceding pictures; overlapping of capitellum by olecranon shadow and backward displacement of capitellum.

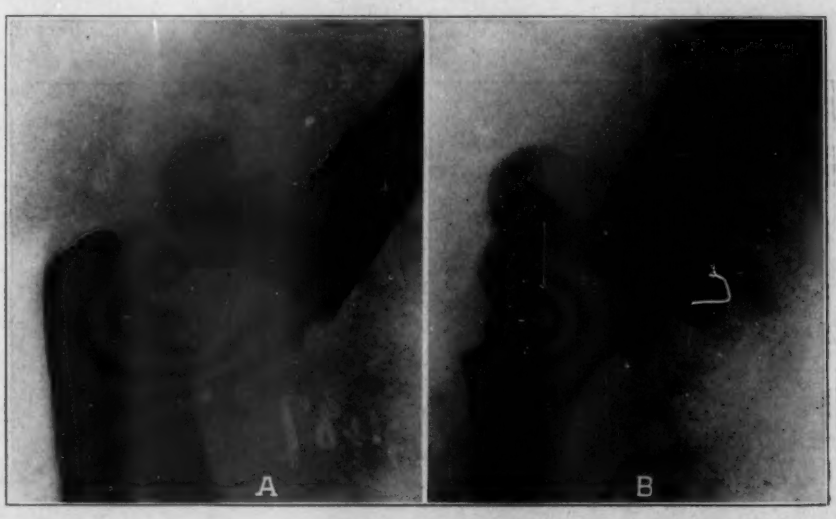


Fig. 14 (Case 10).—Appearance of elbow before attempts at reduction.

## COMMENT

The case of M. S. showed such a marked deformity that an effort was made to overcome it by operation. Before undertaking the operation, the case was studied in the light of our normal pictures. It is easy to understand the limitation of extension as we will note the obliquity backward of the distal end of the humerus in this and other cases with similar deformities. The olecranon meets an obstruction before extension is accomplished, and it no longer can reach the olecranon fossa, but is stopped by the lower end of the humerus. Flexion is impossible because the coronoid probably strikes against the lower end of the humerus before it can reach the coronoid fossa. The problem to be solved, therefore, is a reconstruction of the normal axis of the lower fragment, which means that it must be displaced forward. It

seems logical, therefore, that if a cuneiform section of the humerus is removed anteriorly this will then allow the lower fragment to be flexed or molded into position. This brings the capitellum forward, and it will allow the olecranon to reach the olecranon fossa, as shown by the accompanying illustrations.

In order to accomplish this with the least damage to the periarticular structures, one had best follow the suggestions of James Thompson, of Galveston, in his monograph relative to the approach to long bones. Briefly, they may be stated thus: Deep wounds should be avoided, when the shallow ones will suffice. All nerve supply should be preserved. Unnecessary injury to muscle should be avoided, the work being done between muscles rather than their being sectioned. When section is necessary it should be made as far from the nerve supply as possible. The blood supply should be preserved.

Fig. 15 (Case 10).—*A*, appearance of elbow after attempt at reduction, five days after the accident; *B*, final result. There were complete extension and flexion to 45 degrees and perfect pronation and supination.

In approaching the elbow in this case and in similar cases, these principles were adhered to as nearly as possible.

The procedure adopted was briefly this: An external lateral incision was made, beginning about 2 inches above the elbow, and extending down the forearm a like distance. The brachialis anticus was exposed and the radial nerve was seen prior to its passage through the supinator longus. The supinator was retracted to the inner side of the wound. The periosteum was incised and retracted. It is important not to interfere with the epiphyses. This can be done by making the section above the epiphyseal line, and further by operating from before back-

ward with the muscles well retracted forward. There is no danger of injuring any of the important vessels about the elbow.

CASE 7 (16,088).—L. L., aged 6 years, Sept. 11, 1917, was admitted with a supracondyloid fracture of the humerus. She had fallen from a porch. Several hours after the accident she was brought to the hospital. The arm was hanging by the side, abducted at the elbow more than normal. The entire arm was swollen. Under ether anesthesia, a complete supracondyloid fracture was found. Because of the great amount of swelling, it was impossible to maintain hyperflexion. A Jones elbow extension splint was tried, but the one at hand was too large, therefore anterior and posterior plaster splints were applied.

Fig. 16 (Case 11).—Supracondyloid fracture which was misinterpreted as an "epiphyseal" separation.

September 12: The dressing had to be removed because of swelling. A roentgenogram showed T fracture above both condyles with some lateral displacement.

September 20: There was less swelling of the arm and forearm and less pain. The dressing was changed and the degree of extension increased.

September 27: The arm was placed in complete extension, the elbow was manipulated, and hyperflexion of the elbow was obtained.

A roentgenogram revealed old supracondyloid fracture of the humerus and union with deformity.

Dec. 29, 1917: The patient was able to extend the arm to 160 degrees and to flex it to about 45 degrees.

Oct. 30, 1920: The child came to the clinic in answer to my request. Examination at this time revealed complete extension of the elbow and perfect flexion, no limitation of pronation and supination, and a normal carrying angle. The roentgenogram showed a normal elbow, so far as the lines were concerned, but a premature ossification within the epiphyses of the lower end of the humerus (Figs. 10 *A*, 10 *B*, 11 and 12).

Case 8 (3455).—(Diagnosis: fracture of the external condyle).—*History.*—J. Z., boy, white, aged 9 years, fell from a horse, Feb. 8, 1912. He was seen by Dr. Gessner, February 9, at which time the swelling was so great that he was unable to make use of the hyperflexion position. Instead, however, he put

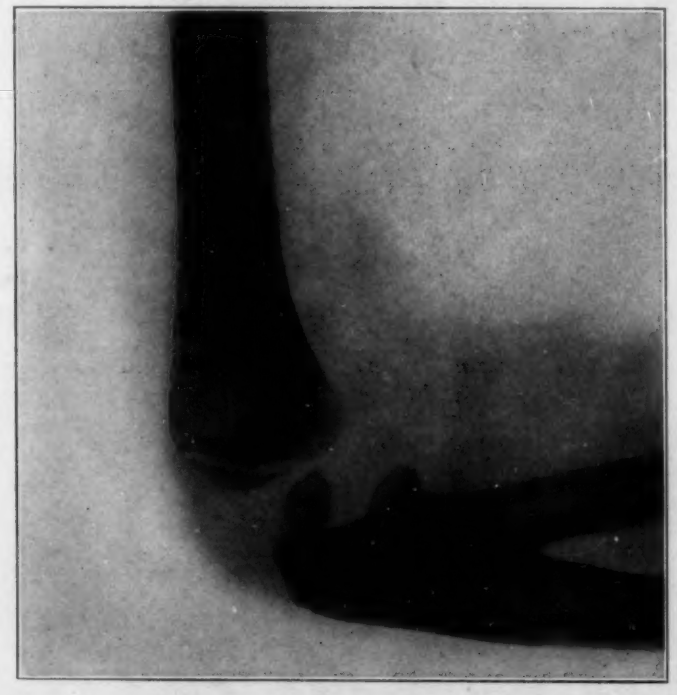

Fig. 17.—Supracondyloid fracture misinterpreted as an "epiphyseal" separation.

the arm at right angles. This position he maintained until February 16, at which time he again tried to hyperflex the elbow, but again the position caused an obliteration of the radial pulse.

*Examination.*—The case was referred to me at the clinic, February 19. Examination at that time revealed a marked deformity, cubitus varus, crepitus over the external condyle, redness and swelling, a small granulating wound over the external condyle.

*Diagnosis.*—Fracture of the external condyle was diagnosed.

*Operation.*—Under anesthesia, the elbow was acutely flexed, the deformity reduced and the parts bandaged as described.

*Subsequent Course.*—He was kept under observation about four weeks, at the end of which time we were trying to obtain some motion in the joint. When last seen, he could flex the arm at an angle of 45 degrees and extend it to an angle of 130 degrees. Letters directed to the father failed to bring the child to the clinic for inspection.

CASE 9.—F. C., boy, white, aged 14, was examined at the clinic April 30, 1912. (The exact data regarding how the accident happened are not recorded). There was evidence of fracture of the lower end of the humerus. The roentgenogram (Fig. 13) demonstrates the exact nature of the injury, there being a

Fig. 18.—Displacement of internal epicondyle in case of separation of this epiphysis.

comminuted fracture of the lower end of the humerus involving both condyles and the olecranon process of the ulna.[1]

The usual treatment was followed, and at the end of four weeks he left the city and I have not seen him since.

1. At present we know that the ulna was not fractured, but the normal epiphyseal line of the unossified olecranon was interpreted as a fracture.

Dr. Maner of Bay St. Louis, Miss., wrote me a letter some time ago and informed me that the boy was able to row and swim with ease.

CASE 10.—*History.*—L. L., admitted, May 10, 1919, five days before while on board a ship fell and injured his elbow. The physician on board considered the injury "a severe sprain" and did nothing, except put a bandage on.

*Examination.*—When the patient came under observation five days later (May 10) there was marked swelling and backward displacement of the elbow, and the forearm was pronated. The forearm extended almost completely; the carrying angle was lost and the hand was swollen.

*Operation.*—Under ether anesthesia, an attempt was made to reduce the deformity. Hyperflexion could not be maintained because of the great swelling. Right angle plaster molded splints were applied.

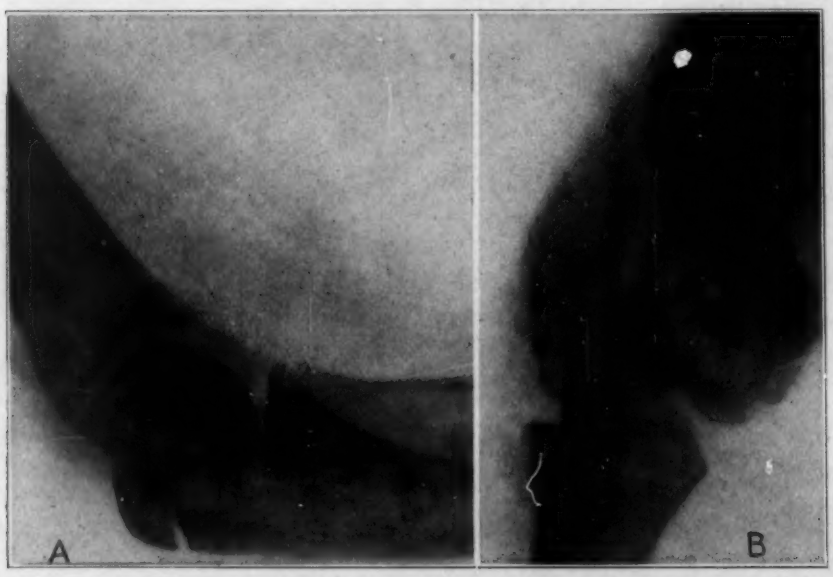


Fig. 19 (Case 13).—Normal joint misinterpreted by roentgenologist as "supracondyloid fracture and separation of olecranon process."

*Roentgen-Ray Examination.*—The roentgenograms made before and after this attempt are shown in Figures 14 *A*, 14 *B* and 15 *A*. Subsequent attempts to reduce the deformity had to be made after the swelling had subsided. The final roentgenogram shows the result.

Dec. 23, 1919: Complete extension was possible and flexion to 45 degrees. Pronation and supination were normal. Roentgen-ray report at this time states: "Perfect union. No evidence of previous fracture except excess of callus on lower anterior aspect of humerus" (Fig. 15 *B*).

### MISINTERPRETATION OF FRACTURES

As a result of my recent study of normal joints in the young I have been interested to note how valuable the information really is when I consider the cases which have previously been reported as having epiphyseal separations.

Citation of a few cases with illustrations will prove the point. Supracondyloid fractures have in the past been misinterpreted by our roentgenologist as epiphyseal separations.

CASE 11 (17970).—M. V. H., girl, aged 4 years, fell from a small wagon and struck her elbow. Pain in the elbow and loss of function are noted on the history card. Roentgenogram 15379: Epiphyseal separation of lower end of humerus. Position good.

The true interpretation in the light of our present knowledge is that there was in this case a supracondyloid fracture—incomplete in the transverse axis of the humerus (Fig. 16).

Under ether anesthesia, the examination was completed. There was no limitation of extension, the carrying angle was not lost, but slightly diminished. The head of the radius rotated with the shaft of the radius.

Fig. 20 (Case 13).—Result in case of fracture of right internal condyle and fracture of left internal condyle of the humerus.

The same error in roentgen-ray interpretation was made in the case of E. M., aged 5 years; "epiphyseal separation of the lower end of the humerus, some slight dislocation of the condyle" (Fig. 17). These mistakes could not have occurred if we had known that the internal condyle does not appear at the ages of the patients in question, and further that the internal condyle when it is apparent is on a level with the internal oblique line of the shaft of the humerus. Any displacement of the internal epicondyle is evidenced by the alteration in its position. Usually it takes a downward position, with relation to the oblique line as is evidenced by the next illustration, which is that of Case 21,915 (Fig. 18).

CASE 12 (17572).—(Notes taken by Dr. H. B. Gessner).—H. C. presented a suspected fracture of the right elbow. A roentgenogram was requested. The roentgen-ray report was: "epiphyseal separation, lower end of humerus." The physical findings were negative.

CASE 13 (17,837).—(Figs. 19*A* and 19*B*).—W. C., aged 15 years, Nov. 14, 1918, presented an elbow which had been swollen since November 12. There was no history of an injury.

Roentgenogram 15234 revealed: Supracondyloid fracture and separation of of the olecranon process of the ulna.

Interpretation at the present time in the light of study of normal joints is that this was a normal joint.

These errors could not have crept in had our roentgenologist known the normal.

## DEDUCTIONS

The roentgen ray can be of inestimable value when proper interpretation is put on the pictures. This can only be done by having a clear knowledge of the normal. In order to compare the roentgenogram of a particular case, we must compare it with the average normal for that particular age, such a series of roentenograms as we have utilized, and which has recently been published.[2]

Fig. 21.—(Case 13).—Result in case of fracture of right internal condyle and left internal condyle of the humerus.

A roentgenogram must not be depended on to show a fracture within an epiphysis in young children before the particular epiphysis has sufficiently ossified.

A knowledge of the normal elbow will prevent future errors by making possible the differentiation of normal epiphyses from fractures.

A disturbance of the relationship of certain planes mentioned in this work will enable the roentgenologist to state that there will be disturbance of function and deformity unless the condition is corrected. This particularly applies to the overlapping of the shadow of the capitellum by the olecranon.

In some instances, there is certainty that the deformity has not been reduced, and from my experience I believe that you can prophecy that a cubitus varus will develop.

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2. Cohn, Isidore: Observations on the Normally Developing Elbow, Arch. Surg. **2**:455 (May) 1921.

Delay in reducing the deformity gives opportunity for swelling to take place, after which the difficulty of treatment is increased, particularly with reference to the hyperflexed position.

Attention must be directed toward developing the external rotators of the humerus, otherwise patients who have supracondyloid fractures have a tendency frequently to continue carrying the arm in the position of internal rotation, which will give rise to a cubitus varus, of muscular origin rather than of bony origin.

The following group of cases is presented in contrast to the preceding groups because they represent the results which follow the applica-

Fig. 22 (Case 15).—Functional result in case of supracondyloid fracture of humerus immediately after fracture and three years later.

tion of principles which are not merely ideas, but convictions in regard to elbow injuries.

The history is of inestimable value; in a broad sense, it includes all of the facts relative to, as well as subjective and objective phenomena associated with, the injury. Many have empirically stated in the past that certain injuries are associated with a certain group of signs and symptoms. What is most to be desired is a diagnosis based on a logical interpretation of historical facts and symptoms as well as

clinical manifestations. Every sign and symptom is present because of a definite anatomic change incident to the lesion present. Examination of an injured elbow should be undertaken in a systematic manner, with a full appreciation of what is to be gained by each step.

The most evident phenomenon on inspection is the position—semiflexion, and diminished or lost carrying angle.

There are many causes for these phenomena. Due attention to each will enable the examiner to reach conclusions which may save the patient much painful manipulation in an attempt to arrive at the final diagnosis. It is not to be understood that it is my belief that inspection will be all that is necessary, but it will be very helpful.

The normal carrying angle is the result of several factors, among which may be mentioned the obliquity of the lower end of the humerus as compared to the shaft of the humerus, and the consequent relative position of the articulation of the ulna with the humerus. Anything which will permit of greater freedom of motion of the ulna in a lateral

Fig. 23 (Case 15).—Functional result.

direction on the humerus will alter the carrying angle. If the above is true, then we must consider the capsule of the elbow as well as the muscular attachments in the vicinity of the condyles.

Turning to our anatomies we find, "The capsular ligament surrounding the joint is very weak behind, stronger in front and very strong at the sides. The sides are commonly called the lateral ligaments. The lateral ligaments radiate from below to the tips of the condyles. The lateral ligaments of the normal joints should always be tense" (Piersol).

From the foregoing, it follows logically that a tear of the lateral ligaments will give rise to an increase in the lateral mobility of the joint. If to the tear of the ligament is added a fracture through one of the condyles, or above the condyles, we will have not only the abnormal lateral mobility, due to the tear, but there will be added

lateral mobility in the direction of the contraction of the group of muscles remaining attached to the shaft, being unopposed by the group torn away from the shaft.

If, therefore, we interpret the exaggerated lateral mobility, as evidence of an injury to the capsule and the contraction of these muscles attached to the shaft, we are in a position then to proceed with further examination, with some knowledge of the probable location of the injury.

Fig. 24 (Case 15).—Functional result.

Palpation always reveals pain at the site of the fracture. If then the two bits of information obtained by inspection and palpation are correlated with anatomic facts, it is reasonable to suppose that it will not be necessary to manipulate a great deal prior to taking a roentgenogram. Manipulation causes pain, and if the patient happens to be a child, as is often the case, the future handling of the case will be more difficult.

The picture must not be accepted as a final statement of the case, if it does not show a condition, belief in the existence of which is justified by examination.

This later statement is based on the fact previously stated that in the young the epiphyses are not evident roentgenographically, and a fracture through one of these does not show.

Under anesthesia, the examination should be continued. Oftentimes the small fragment which was not evident in the picture will be palpated and can be felt to slip back into its normal "bed." Following

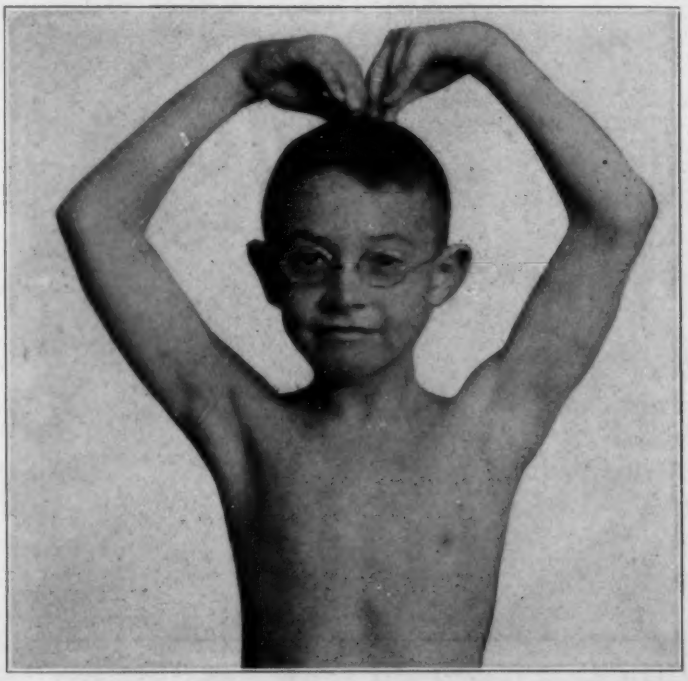

Fig. 25 (Case 16).—Result in case of supracondyloid fracture of the humerus.

such manipulation the carrying angle has been seen to be restored, and flexion and extension accomplished within normal range.

Further it is important after reduction to make a roentgenogram to determine whether the relationship of the capitellum to the sigmoid cavity has been restored. As mentioned before, it should lie well within this cavity and should not be overlapped by the shadow of the sigmoid cavity. If such a condition exists, the deformity has not been reduced, and failure to attend to this detail will result in a cubitus varus. The importance of this cannot be overestimated.

Incidentally, it should be borne in mind that a persistence of this deformity may result from two conditions: a relaxed or stretched

capsule, following the accident, and the overactivity of the internal rotators of the humerus (Case 6, Figs. 9 *A* and 9 *B*).

The importance of the integrity of the internal lateral ligaments has been emphasized by Sir Robert Jones, in connection with operation on the knee. The relaxation of the internal lateral ligament at the knee means a weak and wabbly knee. The same is true of the elbow, and the importance of this source of deformity is too little appreciated.

The position of the forearm with reference to the arm is important: to say hyperflexion and stop is not sufficient, because what is the proper position with one fracture is not the correct one for another. Only by reference to muscle attachments and origins can we be certain of the proper attitude. The rule to bear in mind is always to relax the muscles which are tending to increase the deformity by their contraction, and to bring the axis of the fragments over which you have control into the plane of axis of the fragments over which you have no control, thus producing an equilibrium of forces.

Fig. 26 (Case 16).—Result in case of supracondyloid fracture of the humerus.

Applied to the elbow, this can only be stated by naming the muscles attached about the elbow, and showing by diagrams their particular action, when acting harmoniously and their action after an injury.

It is hardly necessary to restate what has often been stated that hyperflexion is the position of greatest stability in supracondyloid fractures, because the triceps act as a natural splint, and there is a relaxation of all of the flexors which have a tendency to bring the distal fragment into the bend of the elbow.

In fractures of the internal condyle, it is desirable to have not only hyperflexion, but also pronation of the forearm.

This is true because contraction of muscles attached to the shaft, particularly the brachioradialis, tends to supinate the forearm; the supinator brevis which arises from the external condyle and orbicular ligament supinates the forearm, and probably by its contraction, fol-

lowing fractures of the internal condyle, which is often associated with a tear of the internal lateral ligament, tends to diminsh the carrying angle.

The anconeus, which arises from the external condyle and is inserted into the ulna, aids the triceps in extending the arm, and also probably aids in altering the relative axis of the ulna to the humerus, thus exaggerating the cubitus varus deformity.

The contraction of the pronator teres, which originates from the internal condyle, tends to pronate the forearm and by its contraction pulls the loose fragment away from the shaft. Therefore, in order to maintain a position of stability, one in which there will be the least tendency to reproduction of deformity, hyperflexion and pronation will be found most desirable.

In fractures of the external condyle, the position of greatest stability is one of hyperflexion and supination, for these reasons:

Pronation would allow the pronator teres to pronate the forearm and thus pull the external condyle away from the shaft. In supination

Fig. 27 (Case 17).—Result in case of supracondyloid fracture of the humerus.

the pronator is opposed by the artificial force of the bandage, and contraction of the supinator brings the external condyle into closer contact with the humerus.

Reduction having been accomplished and the proper dressing applied, the difficulty often arises of keeping the bandage from slipping from the elbow. It has been found useful to have a conical bag made, the apex down. In such a bag, the hyperflexed forearm and arm are slipped and the whole is supported by tapes tied around the neck.

The after-care is too important not to have a few words said about it.

Prolonged hyperflexion necessarily results in contractures of the flexor muscles. Therefore, it is essential to diminish the flexion as soon as it is safe. This may be begun about the tenth day. At each dressing contrast baths, massage and passive motion are given. The range of motion should be limited by evidence of pain. Pain is indicative of injury to the part. Flexion and extension within a given

arc should be done once at each dressing during the early after-care of these patients.

Plaster molded splints should be used.

A source of annoyance is the tendency toward internal rotation, of the arm as a whole. This is due to the position of hyperflexion, which is accompanied by an internal rotation of the shoulder. In order to overcome this tendency, one must insist on rotation outward of the shoulder at the very earliest moment. Shoulder movement will not disturb the position of the fracture of the elbow if the bandage is snug. Some may consider these statements highly theoretical. To them, I commend neglect of this precaution, and they will later be convinced of the truth.

During the first twenty-four hours, it is urgent that the part be observed closely. Volkmann's ischemic palsy may result from a tight bandage which has been applied for as short a period as six hours. A case which was treated at Touro resulted from the bandage remaining on for twelve hours.

Fig. 28 (Case 18).—Result in case of posterior dislocation of humerus and supracondyloid fracture of humerus.

The application of the bandage in the position of hyperflexion requires special care. All bandages should include the hand. If the bandage does not include the hand, secondary swelling of the hand will be greater than that of the forearm, and any form of gauze sling around the wrist will cause a great constriction at this level. This will create a vicious circle. This difficulty can be overcome by bandaging the hand as well as the forearm and arm. A rubber tube used as a sling is preferable to a gauze bandage, because the elasticity of the former allows for relaxation if swelling occurs.

After the fourth week, it is very important that active as well as passive movement be encouraged. Massage and resistive exercises contribute in a large measure to a perfect result.

The following cases have been treated along these lines and represent the work as it is done in our clinic and private work.

Case 13 (16,915).—J. D., aged 13 years, on April 2, while jumping rope, fell on his outstretched hands. He had had no treatment since the

accident. He had full use of his fingers, but could not raise his arm up to his head nor could he bend the elbow.

April 4, 1918: Examination under ether anesthesia revealed: right elbow, diminished carrying angle, cubitus varus, limited extension and flexion to about 130 degrees; pain on pressure over the internal condyle, crepitus over the internal condyle, and marked deformity. As soon as the deformity was reduced, we noticed a return of the carrying angle.

*Diagnosis.*—Fracture of the internal condyle of the humerus. The arm was placed in hyperflexion. Examination of the left arm revealed that it could be extended and flexed at will. On complete extension of the elbow, the internal condyle was seen to be more prominent. There was undue prominence of the internal condyle; no change in the contour, and small fracture of the internal condyle.

Roentgenogram 12902 revealed fracture of the internal condyle of the right humerus, and fracture of the internal condyle of the left humerus. April 9 and April 20, the arm was redressed. April 22, pronation and supination were unimpaired. There was no loss of carrying angle on either side. May 2, the left arm showed full extension and good flexion: the right arm could be extended to about 130 degrees without pain. All dressings were removed. Report of a roentgenogram, requested June 29, stated: "Suggestive of an old fracture, but

Fig. 29 (Case 21).—Result in case of fracture.

position is exceptionally good" (No. 14380). Examination, Nov. 20, 1920 (two years and a half after accident) revealed: perfect extension, perfect flexion, normal carrying angle, and no loss or limitation of pronation or supination (Figs. 20 and 21).

Case 14 (17873).—*History.*—A. C., white, aged 10 years, admitted Nov. 21, 1918, with a supracondyloid fracture, the evening before had been pushed down while at school. When he fell, the arm went under him. He was unable to bend the elbow. He was treated by Dr. Levy in the emergency clinic.

*Examination.*—The left forearm was swollen; the carrying angle lost; the external condyle was lower than the internal condyle, and there was no alteration in the contour of the olecranon. Under ether anesthesia (Miss Armstrong) abnormal lateral mobility was noted. The deformity was reduced and the usual dressing applied. Roentgenogram 15272 revealed: Fracture lower end of the condyles of the humerus, epiphyseal separation of the olecranon process, epiphyseal separation of the head of the radius (Samuel).

*Treatment.*—November 30, hot and cold baths were employed. A splint was applied at a right angle. December 7, extension and flexion of the elbow were accomplished without pain. December 12, all dressings were removed.

*Outcome.*—The patient was seen during November, 1920. He had perfect extension and flexion of the elbow; no loss of carrying angle, and no loss of pronation and supination.[3]

CASE 15.—Feb. 10, 1917. G. M., boy, white, aged 12 years, was admitted with a fracture of the radius near the base— supracondyloid fracture of the humerus. He had fallen on the outstretched hand.

Examination revealed swelling about the elbow; abnormal lateral mobility, and crepitus. Above the wrist, there was a backward displacement of the hand on the forearm. Roentgenogram 98832 revealed: fracture of the lower end of the radius and supracondyloid fracture of the humerus (Fig. 22).

The deformities were reduced under anesthesia. Hyperflexion was maintained by light plaster splints.

March 13, 1917, flexion was 30 degrees, extension to 130 degrees. There was no pain and no deformity. March 24, he was able voluntarily to extend the elbow to 150 degrees without pain. There was no deformity. Pronation and supination were unimpaired (Fig. 23).

Fig. 30 (Case 21).—Result in case of fracture.

April 3, supracondyloid fracture position was fairly good. At my request the child appeared in the clinic Oct. 30, 1920. Examination at that time showed perfect function of the elbow, complete extension and flexion. There was no limitation of pronation nor supination. He had a normal carrying angle. A roentgenogram requested at this time revealed a normal elbow joint. About 2 inches above the level of the joint, there was evidence of a previous line of fracture (Figs. 24 *A* and 24 *B*).

*Comment.*—(1) The combination of a fracture of the base of the radius following a fall on the outstretched hand requires not only the hyperflexed position but in addition a palmar plaster splint.

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3. The epiphyseal separation of the olecranon mentioned by the roentgenologist did not exist. It represents one of the stages of the normal development of the elbow as described in a previous paper (Footnote 2).

Case 16 (20605).—H. G. aged 7 years, admitted Jan. 10, 1920, with a supracondyloid fracture of the left humerus. Sunday evening, Jan. 4, 1920, the patient had been running along the street when he fell in the gutter on his left arm. He came to the hospital the same evening and had a cast put on. He went home after a week's stay in the hospital. The arm was put up, January 10, in the Smith-Jones position. He returned January 12, and the arm was redressed. He has been anesthetized three times, once in my clinic. January 15, a right angle splint was applied.

January 24, flexion was limited and painful; a splint at 160 degrees was applied. Roentgen-ray report, Jan. 27, 1920: Old supracondyloid fracture of the left humerus, with some backward displacement of the lower fragment.

The child was resistant to any effort to do anything for him. The mother was advised to continue contrast baths and carrying of weights.

February 12, the child was resistant to treatment. The elbow was flexed and he would not allow one to extend it. The mother was advised of poor result unless she forced the child to carry out the treatment. He was able to extend the arm to about 150 degrees. He flexed the elbow to 60 degrees. Hot and cold applications and exercise were continued.

February 28, flexion and extension were still limited. Pronation and supination were limited. The same treatment was continued.

Fig. 31 (Case 22).—Result in case of supracondyloid fracture of the humerus.

March 13, flexion and extension were still slightly limited. There was still a large amount of callous surrounding the old fracture (supracondyloid). Forced hyperflexion was painful.

November, 1920, at my request, the child came to the clinic for observation. At this time, examination revealed: complete flexion, pronation and supination, and extension, and a normal carrying angle in both elbows (Figs. 25 and 26).

*Comment.*—The original attempts at reduction made by others did not succeed. When I saw the child, there was so much swelling that hyperflexion could not be maintained.

Persistent after-care will overcome many apparent muscle contractures.

Case 17 (17923).—F. B., Harrahan, La., boy, white, aged 10 years, was admitted Nov. 5, 1918 with a supracondyloid fracture. He had fallen in a ditch, December 3, and had struck the left elbow. He was unable to straighten the arm or to bend the elbow. The left forearm was swollen. Measurements of the left elbow were 21 cm., right 17 cm. There was no pain over either condyle and no pain over the olecranon process. The head of the radius rotated with the shaft. He did not complain of pain along the course of the ulna. There was a diminished carrying angle. The fracture was reduced

under general anesthesia, and the usual dressing was applied. Roentgenogram 15365 revealed: epiphyseal separation lower end of the condyles of the humerus.

December 12: A right angle plaster splint was applied.

December 21: All dressing was removed.

April 22, 1919: There was no limitation of flexion or extension. The carrying angle was normal. The child said, when asked what he did with the arm, "I do all I want."

At my request the child came to the clinic Nov. 20, 1920. There was a normal carrying angle; no difference in the size of the two elbows; no limitation of flexion or extension of the two elbows. Pronation and supination were unimpaired (Fig. 27).

Roentgenogram 24247 revealed no visible bone injury of the left elbow (Nov. 20, 1920).

CASE 18 (17205).—A. K., boy, aged 10 years, admitted June 8, 1918, with a "posterior dislocation of the elbow—supracondyloid fractures." He had fallen from a bicycle the day before and had struck his elbow on the car track. He was able to raise the arm, but could not bend the elbow. Examination revealed swelling and ecchymosis of the right elbow, abnormal mobility, no change in the contour of the ulna, abnormal mobility and crepitus just above the condyle.

Fig. 32 (Case 22).—Result in case of supracondyloid fracture of the humerus.

Under ether anesthesia, the deformity was reduced. On account of the great amount of swelling around the elbow it was impossible to put it up in hyperflexion, anterior and posterior plaster splints were made, and the arm was put up at a right angle. A roentgenogram was requested.

June 13, the swelling had disappeared, and we were able to put the arm up in hyperflexion.

At my request the child came to the clinic, Nov. 18, 1920. There was no limitation of flexion nor extension, and no loss of carrying angle. Resistive exercise showed no loss of muscle power; if anything, the right arm showed better muscular development than the left (Fig. 28).

CASE 19 (21317).—R. L., girl, aged 3 years, was admitted June 17, 1920, with a supracondyloid fracture. She suffered pain in the left elbow. She had fallen from a sofa the night before and following the fall the arm hung by

her side. She cried a great deal, complaining of pain. There was swelling and ecchymosis of the left elbow. The lateral diameter was increased and there was a diminished carrying angle. Flexion and extension were limited.

Roentgenogram 21927, June 21, 1920, revealed a fracture through the condylar lower end of the humerus, the left elbow joint. Position was fairly good.

June 24, 1920: There was swelling of the elbow, with marked cubitus valgus. Under ether anesthesia, the deformity was reduced.

June 26, 1920: The child did not complain of pain; she could move the hand. The dressing was not changed; adhesive plaster reenforcement was applied. There was no swelling.

July 6, 1920: Flexion and extension were still slightly limited. A palmar plaster splint was reapplied.

July 10, 1920: The splint was removed. Contrast baths and exercise were employed. The arm was held in external rotation, and there was perfect flexion and extension.

Case 20.—L. M., girl, suffered a supracondyloid fracture (impacted). While playing with one of her little friends she was thrown down and fell on the outstretched hand. On examination in the office, I found that there was swelling above the elbow, diminished carrying angle, cubitus valgus, and inability to flex and extend the elbow. A roentgenogram revealed supracondyloid fracture

Fig. 33 (Case 23).—Result in case of supracondyloid fracture of the humerus.

with impaction. Under gas anesthesia (Miss Armstrong), the impaction was broken up by hyperflexion, traction and counter traction, and I was unable to put the arm in acute flexion owing to the large amount of swelling which had taken place. It was put up at a right angle, that being all we could do at the time. The after-care was that usually given. January, 1921: The final result was perfect.

Case 21 (15350).—E. G. B., boy, aged 10 years, suffered a fracture of the internal condyle of the humerus. While playing baseball, he threw the ball, and a sudden pain developed in the right elbow. There were pain, swelling, and abnormal mobility. The right elbow was larger than the left. The right measured 7¾ cm, the left 7⅛. The attitude was one of loss of carrying angle. He held the right arm partially extended. There was marked swelling above the internal condyle, and no change in normal relationship of landmarks of the elbow, but there was considerable pain over the internal condyle. Flexion beyond a right angle was impossible on account of pain. Bandages were removed and right angle splints were applied. Roentgenogram 10570 revealed "epiphyseal separation of the condyles of the humerus." Position was fairly good.

April 22, 1919, there was no limitation of flexion or extension. There was normal pronation and supination, and no deformity (Figs. 29 and 30).

CASE 22 (15805).—R. B., aged 10 years, suffered a fracture of the internal condyle. She fell from a wagon, July 27, 1917, and injured her elbow. Examination revealed complete loss of carrying angle, swelling of the elbow, pain over the internal condyle, and all motions about the elbow painful.

Roentgenogram 11142 revealed a supracondyloid fracture of the humerus. Position was good. Under ether anesthesia, the deformity was reduced, the carrying angle returned, and the elbow put in hyperflexion. On the tenth day the hyperflexed position was changed to one of right angle. There was no pain.

Sept. 13, 1917: Extension was possible to 160 degrees; flexion beyond 45 degrees. There was no pain nor deformity. The patient was advised to continue exercise.

Sept. 29, 1917: There were perfect flexion and extension.

Nov. 9, 1920: At my request the patient appeared in the clinic for observation, at which time the following was noted: carrying angle of both elbows was the same; there was no limitation of flexion, pronation or supination (Figs. 31 and 32).

Fig. 34 (Case 23).—Result in case of supracondyloid fracture of the humerus.

CASE 23 (18630).—G. O'B., aged 14 years, admitted June 13, 1919, with a supracondyloid fracture of the humerus, had fallen about 4 feet, striking the left arm on the pavement. There were swelling and pain around the elbow, an ecchymotic area over the external condyle, and crepitus on palpation. The transverse diameter of the elbow was increased. Under anesthesia the elbow was placed in hyperflexion.

Roentgenogram 16832: "The left elbow joint shows a supracondyloid fracture" of the left humerus. There is a splitting into the olecranon process of the ulna.

June 14, 1919: The patient had not suffered any pain.

June 22: The dressing was removed. There were ecchymosis and swelling over the external condyle. The arm was placed at a right angle in complete supination, and a plaster splint applied.

June 24: It was placed at an angle of 110 degrees.

June 28: It was placed in almost complete extension.

July 1: There were flexion to about 60 degrees and complete extension. A straight plaster splint was applied.

July 3: The splint was reapplied.

The roentgen-ray report was: "Repair of fracture previously observed is excellent; but there is a decided thickening of the periosteum throughout the lower shaft of the humerus," July 3, 1919.

One year and five months after the accident, Nov. 8, 1920, there was a normal carrying angle; perfect flexion and extension; no limitation of pronation nor supination (Figs. 33 and 34).

CASE 24 (21404).—E. C., aged 7 years, admitted July 3, 1920, with a fracture of the internal condyloid region (left), had fallen on his arm the night before. He slept that night; but there was immediate loss of function.

Examination revealed swelling of the left antecubital space, slight loss of carrying angle, and localized pain over the internal condyloid region. Flexion and extension were slightly limited and painful. The head of the radius rotated with the shaft. No crepitus could be felt. A roentgenogram was requested. Under ether anesthesia the arm was put in hyperflexion.

July 10: There was some ecchymosis and swelling around the external condyloid region. Extension and flexion were painful and limited. The arm was put up in right angle. July 15, flexion and extension were still limited and painful. The arm was put to 100 degrees. July 20: Extension was slightly limited and painful. Flexion was limited to 30 degrees. An anterior plaster splint was applied.

July 24: All splints were removed. Contrast baths and massage were advised.

July 29: Flexion and extension were still limited.

August 10: There was no deformity. Flexion of the forearm was still limited. Pronation and supination were not limited.

Nov. 9, 1920: I requested the patient to return for observation, at which time the following was noted: flexion and extension not limited; pronation and supination normal.

CASE 25 (13918).—C. H., aged 8 years, admitted July 1, 1916, with a supracondyloid fracture of the humerus, had fallen in the gutter the afternoon before. She was treated in the emergency clinic by Drs. Park and Wall and me. Examination revealed swelling of the elbow, abnormal lateral mobility, and pain. The condyles and olecranon were in normal relationship to one another. The shaft was independent of the condyles. Reduction was accomplished under anesthesia, and acute flexion obtained. Roentgenogram 8602: Supracondyloid fracture of the humerus; position of fragments not good.

The dressing was changed and a right angle position revealed.

April 22, 1919: Flexion and extension were normal. There was no loss of carrying angle. Pronation and supination were unimpaired.

CASE 26 (12954).—S. S., aged 11 years, admitted Nov. 27, 1915, with an old fracture of the internal condyle and ankylosis, four weeks before had fallen and hurt his arm. He was sent to the Charity Hospital where he was treated for fracture. He was discharged from the hospital and came to us. The arm was painful to the touch. Motion of the elbow was limited. There was deformity upward and backward at the elbow. Roentgenogram 7408: Fracture of internal condyle and fracture of the olecranon process. Position is not good.

April 22, 1919: There was no limitation of flexion nor extension. Pronation and supination were unimpaired. There was no deformity.

CASE 27 (18085).—S. B., aged 14 years, was admitted Jan. 30, 1919, with a fracture of the internal condyle. The history was written and roentgenogram 15668 was made March 1, 1919. The boy had fallen on his outstretched hand while playing leap frog. The roentgen-ray report was: fracture of the olecranon and other fractures. I examined the child, February 15. There was no pain over the olecranon, but pain over the internal condyle, and some limitation of flexion and extension, more of flexion.

A diagnosis of fracture of the internal condyle was made, and the arm was put in hyperflexion. Since that time, hyperflexion has been reduced until now, March 1, there is complete extension. All dressings were removed. The patient was advised to get a pair of dumb bells, and requested to return to clinic.

March 18: There was no limitation of extension or flexion. There was pronation and supination, and no pain. The use of dumb bells and contrast baths was advised.

April 22: There was no limitation of pronation and supination and no deformity.

CASE 28 (17650).—J. C., boy, colored, aged 9 years, was admitted Aug. 27, 1918, with a supracondyloid fracture. Ten days before he had fallen and struck his elbow (right). He had been unable to use the arm since the injury. The elbow was very much swollen. The child was put under ether anesthesia by Dr. Parish. The right elbow was swollen. The left elbow measured 8 inches; the right, 7½. There was no difference in the two condyles or the olecranons. Under anesthesia there was abnormal lateral mobility and crepitus. On account of the great amount of swelling, it was impossible to put the elbow up in hyperflexion, because of possible injury to the vessels. The arm was placed at a 160 degree angle, with a posterior plaster splint.

September 10: The dressing was removed, contrast baths and massage given, and splint reapplied.

September 14: Contrast baths and massage were given, a straight plaster splint was applied.

September 17: The dressing was not changed.

September 19: Pronation and supination were unimpaired. There was no pain and no loss of carrying angle. All dressings were removed. The use of dumb bells and contrast baths was advised.

October 5: The child was able to extend the arm almost completely.

CASE 29 (14710).—E. A., aged 5 years, suffered a supracondyloid fracture (left). She had fallen the day before (Nov. 24, 1916) while playing. Immediately there was loss of function. She cried all night and was in pain.

Examination revealed cubitus varus and swelling. There was pain in the internal condyle, and inability to flex the elbow.

Under anesthesia, reduction was made, and the arm was placed in hyperflexion.

Jan. 10, 1917: There was complete flexion and extension without pain and no deformity.

CASE 30 (17624).—A. H., white, aged 6 years, suffered a supracondyloid fracture.

While running the night before (Aug. 29, 1918) the child fell over a box and struck his elbow. He was treated in the Emergency Clinic on the same date and reduction was made by me.

Roentgenogram 14804 revealed: Supracondyloid fracture—position is fairly good (Dr. Samuel).

Examination under ether anesthesia revealed abnormal lateral mobility, some crepitus, and a loss of carrying angle. The arm was put up in the usual dressing.

The patient returned the next morning; he had no pain, and the dressing was allowed to remain unchanged.

September 17: The patient did not return for ten days; there was then some limitation of motion of the elbow, but particularly contraction was noted. The father of the patient was advised of the fact that he would have to return when told. The arm was put up at an obtuse angle. Contrast baths and massage were given. October 14, all dressings were removed. The use of dumb bells and hot and cold water was advised. The result was perfect.

CASE 31 (21,338).—L. T., colored, aged 13 years, was admitted, June 22, 1920, with a supracondyloid fracture of the left humerus. He had fallen from a bicycle three weeks before and injured the left arm. He had been to Touro several times for treatment.

An examination made three weeks before revealed loss of the carrying angle of the left arm. Cubitus varus and crepitus *above* condyle. There was increase of the lateral diameter. Under ether anesthesia the fracture was reduced, and the arm put in hyperflexion. Patient did not return as told until today. Flexion of arm was limited to 90 degrees and extension to 90 degrees. Plaster splint was applied.

Roentgenogram 22,045 revealed fracture of the lower end of the humerus; position very good.

July 6: Flexion was still limited to 90 degrees; extension normal. The splint was removed and the use of contrast baths was advised.

Final result: Perfect flexion and extension.

CASE 32.—L. G., aged 11 years, was admitted, June 10, 1919, with a supracondyloid fracture. He had fallen on the left arm eleven days before. He had been treated by Dr. Robinson in Pass Christian the day of the accident. There was no history of any pain. He was unable to straighten the arm.

The arm had been put at right angles by the other physician. There was evidence of pressure from the bandage. The patient was unable to straighten the forearm. Roentgenogram 16,829 revealed: Epiphyseal separation of the lower end of the left humerus.

Right angle plaster splints were applied. There was pain on extension over the external condyle; pronation and supination were not painful. The dressing was changed and the forearm put at a 110 degree angle.

June 26: The dressing was put on at an angle of 160 degrees.

July 1: Straight splints were applied. Extension and flexion were almost complete.

July 3: All dressings were removed. The mother was told to get two pound sand bags.

July 10: The child was afraid to use sand bags. He was able to extend his hand to an angle of 160 degrees, and to flex it beyond a right angle.

July 31: Complete extension and flexion were possible without any difficulty.

1211 Maison Blanche.

# TORSION OF THE CECUM AND ASCENDING COLON*

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BOSTON

Torsion or volvulus of the right side of the colon is one of the rare causes of intestinal obstruction. Though much less often mentioned in the literature than sigmoid volvulus, and less often encountered in surgery, it is probably of greater importance in the usual surgical clinic for adults, since twists and obstructions of the sigmoid are almost invariably associated with congenital megacolon (Hirschsprung's disease), a condition which in many instances becomes fatal or is successfully treated in infancy and childhood. Indeed, in this clinic, the count stands three cases to none in favor of the ascending colon.

The pathology of this accident rests on certain well studied congenital maldevelopments, plus a functional disturbance, in which a most interesting and little understood factor is the power of rapid gas formation possessed by the intestinal canal. As a sine qua non for the development of a twist of the right colon, it must have a mesentery. In addition, there may well be a displacement: of the cecum into the middle or left side of the abdomen, of the cecum upward, so that it is turned up against the liver, of the ascending colon, which may be displaced with the cecum, or (the cecum being fixed in its proper place) of the ascending colon as a downward hanging loop with or without attachment at its familiar angle beneath the liver. With the probable exception of the upturned cecum, such malformations are accounted for as failures of obliteration of the fetal mesentery rather than failures of descent of the right colon, a condition of little interest in this connection. Figures 1, 2, 3 and 4 illustrate these malformations.

In regard to the functional element in the causation of obstructive twists, physiologic studies by Cannon,[1] by Elliott and Barclay-Smith,[2] by Keith,[3] and others offer evidence of more than speculative interest. Cannon demonstrated that in the cat the receptively relaxed cecum and ascending colon, on receiving the liquid contents of the small intestine, undergo activity in the form of an antiperistalsis which

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*From the Surgical Clinic of the Peter Bent Brigham Hospital.

1. Cannon, W. B.: The Functions of the Large Intestine, J. A. M. A. **59**:1 (July 6) 1912.

2. Elliott, T. R., and Barclay-Smith, E.: Antiperistalsis and Other Muscular Activities of the Colon, J. Physiol. **31**:272, 1904.

3. Keith, A.: A New Theory of the Causation of Enterostasis, Lancet **2**:371, 1915.

retards and churns their contents for a considerable period, a delay which favors equally fermentation and the absorption of fluid. This observation has since been confirmed and amplified by Elliott and Barclay-Smith. Whether or not the right colon of man is the seat of a similar process, the human colon, herbivorous in type, is undoubtedly the scene of the final fermentation and putrefaction of such food materials as are indigestible above; and, in particular, the cecum and ascending colon constitute a region of purposeful stasis and fermentative digestion.[4]

The government of the muscular activity of this region has likewise been considerably studied. Cannon, and subsequently Alvarez,[5] has shown in laboratory animals that contractions spreading from the lower portion of the ileum excite the initial activity of the beginning of the colon. In addition, there is a pacemaking area in the transverse colon, just around the corner from the ascending colon, which initiates the antiperistaltic contractions already described.[6]

According to Keith, this delaying station forms one of the most important members of a chain, of which two others are found in the large intestine, namely, at the rectocolic junction and above the anal canal.

It is clear then that the normally placed and fixed right colon is the seat of rather complicated physiologic activities on whose harmony depends the last of the digestive process and the formation and elimination of the feces. Familiar disturbances may well upset this harmony, bringing about unusual putrefaction and gas formation and leading in a dislocated or perhaps merely free bowel to acute distention, kinking and volvulus. Or, as has occasionally been reported, unusual muscular movements of the body, may, with or without such digestive

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4. For a discussion of antistalsis or anastalsis in the proximal colon, see Cannon, Footnote 1.

5. Alvarez, W. C.: Peristalsis in Health and Disease, Am. J. Roentgenol. **8**:1 (Jan.) 1921.

6. Gunn and Underhill (Experiments on the Surviving Mammalian Intestine. II. The Myogenic Origin of the Pendulum Movements, Quart. J. Exper. Physiol. **8**:285, 1914-1915) first demonstrated that the intestinal muscle, independently of any nerve supply, has the power of rhythmic contraction. This discovery controverted the earlier results of Magnus who found the presence of fibers of the myenteric plexus essential to such activity. Alvarez has abundantly demonstrated the power of the intestinal muscle independently to perform rhythmic contraction and has shown that it presents gradients starting from certain commanding stations, one of which is found in the region just distal to the ascending colon. This region again is indicated by Keith as abundantly supplied by peculiar branching cells not definitely of nervous or muscular nature but partaking of the character of both, and interpreted by him as a special development of the myenteric (Auerbach's) plexus. Alvarez would give the plexus a regulatory function only.

disturbances, produce the same result. In any case, once a kink or twist begins to interfere with the blood supply, the bowel so affected blows up rapidly, a fact noted many years ago by Treves,[7] who reports that the same result may be obtained experimentally. The mechanism of this rapid gas formation, which never takes place to the same degree proximal to the obstruction, is not understood.

In respect to the form or nature of the twist, descriptions in the older literature, based for the most part on fatal cases studied at necropsy, are perhaps misleading. One is more likely nowadays to see earlier stages on the operating table. Of present day value, however, is the observation by Treves of three forms of torsion. The first may involve the cecum and ascending colon in their own axis. In the second,

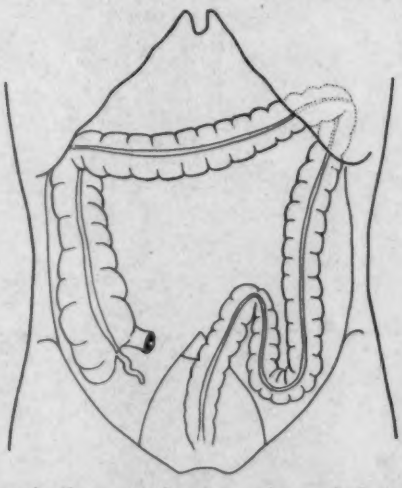

Fig. 1.—The theoretically normal colon. A much lower hanging transverse colon is usual.

the ascending colon may, with or without the cecum, possess so long a mesentery that it forms a loop which itself may rotate or become locked about another intestinal coil. In the third, the cecum may bend or twist on itself. The first variety, which does not necessarily involve any malformation or the presence of a *long* mesentery, is said to be very rare. The second, in which the ascending colon forms a loop, is about as frequently seen as the third, which occurs as a result of displacement or malformation of the cecum alone. One finds in the literature, a general agreement that twists occur clock-wise, an observation explained by von Zoege-Manteuffel [8] as due to the mesenteric

7. Treves, F.: Intestinal Obstruction, Ed. 11, New York, William Wood & Co., 1899, p. 13.

8. Von Zoege-Manteuffel: Die Achsenderhungen des Coecums, Verhandl. d. deutsch. Gesellsch. f. Chir. **27**, Part 2:546, 1898.

attachment of the ileum. Basing his conclusions on twenty collected cases and four of his own, this observer concludes that torsion to 180 degrees may occur in the axis of the bowel without interfering with its blood supply, but that if the twist goes beyond this point, the mesentery, which is necessarily present, becomes strangulated.

The importance of all these etiologic factors is easily seen when one faces the treatment of this condition. For having them in mind, one can more easily decide on simple drainage, fixation, or resection of the diseased colon. The three patients whose cases are herewith described had suffered for years from obscure abdominal complaints which apparently culminated in acute torsion; and whatever palliative treatment might previously have been indicated, operation was finally in all instances imperative.

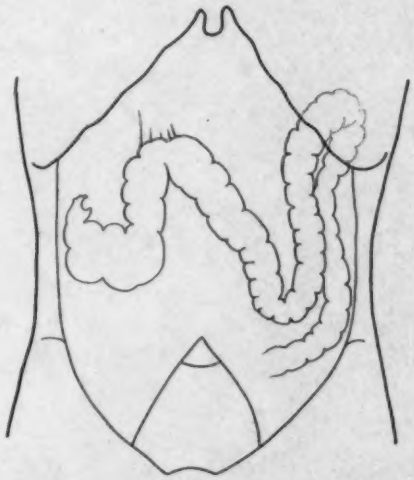

Fig. 2.—Sketch made from roentgenogram. The cecum is fixed in a high position. (A defect due to an early cancer is seen at its tip.) The ascending colon has a mesentery and hangs down below and mesial to the cecum. The hepatic flexure is attached rather near the midline.

## REPORT OF CASES

CASE 1.—*History.*—E. C. M. (Surg. No. 5,222), female, aged 32, three years before entrance to the hospital, had been operated on for appendicitis. Since then she had suffered a number of attacks of acute low abdominal colic, accompanied by distention and constipation. Milder attacks were relieved by lying on the left side, after which the patient passed gas and felt better. The more severe attacks lasted from four to five hours and were relieved by enemas. She was wakened three days before entrance to the hospital by colicky abdominal pain. Cathartics and enemas gave no relief. Since then the abdomen had become distended. The abdominal enlargement was first noted on the left of the umbilicus and was accompanied from the start by visible peristalsis. The patient constantly vomited food taken, but no regurgitation of intestinal contents occurred.

*Examination.*—On entrance, the patient's temperature was 100 F., pulse 96, white count 12,000. There was a median scar below the umbilicus. The abdominal distention was most marked in the region just below the umbilicus, beginning a little to the left of the midline and extending upward to the right for about 8 inches. The right iliac fossa was a little less distended. There was no fulness in the flanks. It was noted that in spite of what appeared to be obstruction in the lower ileum, the patient did not look particularly sick.

*Operation.*—At operation, through a right rectus incision, the cecum and lower ileum were found adherent to the upper end of the median scar and to the posterior abdominal wall as well. The cecum had then pushed downward and to the left through the attachments thus formed, and had twisted, as one looked at the cecum from above, clock-wise. (The exact amount of the torsion was not recorded; certainly not more than 180 degrees.) The cecum was enormously distended, thin-walled, but not notably cyanotic. The adhesions were divided. After tying in a Mixter tube, it was possible to replace the cecum and ascending colon in their normal position. The patient made a good recovery, the colostomy closed naturally in about three weeks, and aside from her habitual constipation, the patient, during the five years which have followed her operation, has been well.

The postoperative condition of the cecum, ascending colon and large intestine in general is well illustrated in Figure 5, a sketch made from a roentgenogram of a barium enema. There is evidently considerable redundance of the large intestine both on the right and left side, a tendency noted by Leichtenstern,[9] Curschmann,[10] and others in their studies of large intestine abnormalities.

Case 2.—*History.*—J. E. McG. (Surg. Nos. 11,969 and 12,220), male, aged 53, for fifteen years had experienced attacks of discomfort confined to the lower abdomen and appearing after meals. At first, these attacks appeared about once a month. For the last two years, they had become more frequent and severe, lasting sometimes from five to six hours. Induced vomiting had always given relief.

Ten days before admission to the hospital, the attacks began to appear daily, the pain, of a dull grinding character, became more severe and vomiting followed the taking of food. The bowels continued to move naturally until four days before entrance when an enema gave a good result. From that time on there were no movements.

*Examination.*—On admission, the temperature was 98 F., the pulse 84, and the white count 25,000. The patient was somewhat cyanotic but did not appear very sick. The abdomen was moderately and symmetrically distended. There was evidence of a little fluid. A cleansing enema gave a fair gas result, and a barium enema disclosed in the roentgen-ray examination the condition shown in Figure 6, a sketch taken from the roentgenogram. The cecum was enormously distended and the ileocecal valve dilated.

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9. Leichtenstern, O.: Verengerungen, Verschliessungen und Lageveränderungen des Darms, Handbuch der Speciellen Pathologie und Therapie **7**, Part 2:361, 1876.

10. Curschmann, H.: Topografhisch-klinische Studien, Deutsch. Arch. f. klin. Med. **53**:1, 1894.

*Operation.*—Lying in the midabdomen was an enormous tense cecum, whose walls were beginning to split along one of the longitudinal bands. There appeared to be no interference with the blood supply. After needle puncture of the bowel had emptied the cecum and ascending colon, palpation demonstrated that the transverse colon was collapsed and the hepatic flexure fixed. A twist could not be demonstrated. Cecostomy was followed by a good recovery.

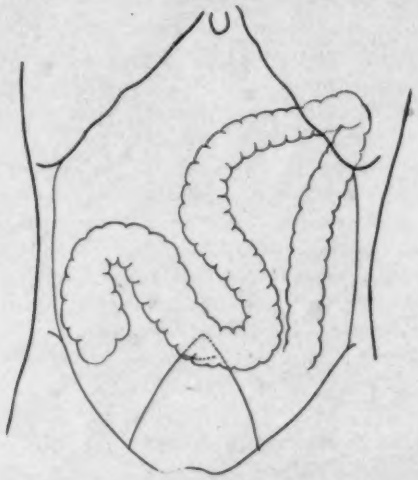

Fig. 3.—Sketch made from roentgenogram. The cecum is normally fixed. The ascending colon has a long mesentery and hangs down into the pelvis. There is no hepatic flexure.

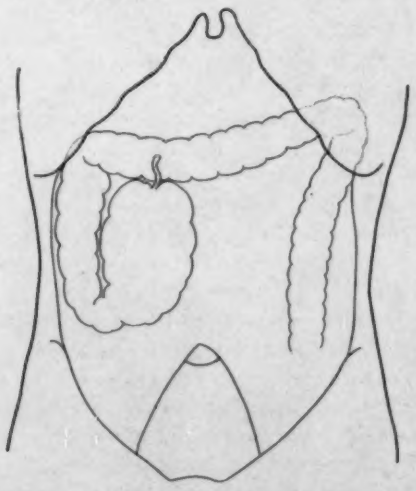

Fig. 4.—Sketch after Curschmann. The cecum has been "hung up" in its descent. The upper part of the ascending colon is normally placed and fixed.

After the opening had spontaneously closed, the bowels moved well and roentgen-ray studies revealed a normal passage of food through the intestines. Within a week after closure of the colostomy, the attacks recurred, causing the patient again to enter the hospital. Relief by enema has been followed by normal health up to the present, one year later.

Evidently the fixation due to the cecostomy has cured this patient. The lesion here was possibly a valvelike kink rather than a twist. The barium examination previous to operation showed that fluid could enter the ascending colon from below but could not return, and since a twist would probably have disturbed at least the venous circulation, absence of cyanosis in the bowel wall suggests that no twist existed. In this respect this case somewhat resembles Case 3.

CASE 3.—*History.*—M. E. B. (Surg. No. 13778), female, aged 44, had been troubled all her life by "indigestion." For the last eighteen years, she had suffered at irregular intervals from attacks of nausea and constipation alternating with diarrhea. For these attacks, which, if untreated, lasted many days, she had learned to take castor oil followed by a glycerin enema. She then passed a good deal of foul material and mucus by rectum, and went on as before. Removal of the appendix two years after the beginning of her illness had not affected this condition.

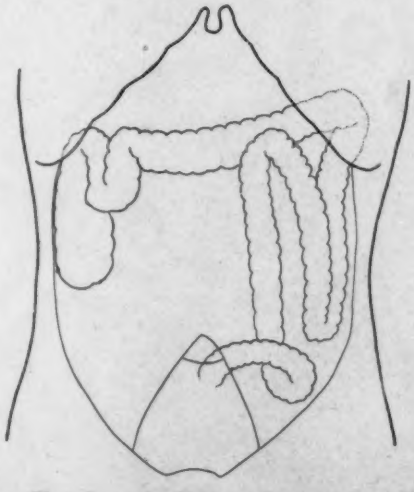

Fig. 5. (Case 1).—Sketch made from roentgenogram showing postoperative condition. The cecum and ascending colon are now in normal position and apparently fixed (following colostomy and operative trauma). There is a redundancy of the ascending (or transverse) colon. The extraordinary loop of descending colon may be noted.

Ten days before entrance to the hospital, one of the familiar attacks began, but was not relieved by the usual remedies. Up to the day of entrance, the patient felt nauseated and uncomfortable at times. Feeling more abdominal discomfort on this day, she took a glycerin enema with fair result, but within half an hour she began to suffer the very same cramplike pain in the right iliac fossa, which six hours later led to operation. Morphin (¼ grain) gave little relief. At the same time, a swelling appeared in the abdomen close to the right flank and steadily increased in size until, when seen in the evening, an elongated rounded mass occupying the normal position of the cecum and ascending colon was very evident. This mass was tender to touch, but elsewhere, the

abdomen was soft and not distended. The patient's temperature was subnormal; the pulse rapid. She was evidently in moderate shock. A diagnosis of torsion of the cecum and ascending colon was made.

*Operation and Results.*—Six hours after onset, a muscle splitting incision was made in the right flank. There was a little free clear fluid in the abdomen. A much dilated large intestine of dusky color appeared, running from the rib border to the iliac crest. At first sight, this appeared to be the ascending colon; but when collapsed large intestine was seen in the flank outside it, the dilated intestine was thought to be a descending turn of the transverse colon lying in shotgun fashion median to the ascending. The patient's rather feeble condition permitted nothing more than a colostomy, made with a Mixter tube. The contents of the distended colon were for the most part a clear greenish-brown fluid, sometimes stained with dark blood. A good deal of gas was evacuated.

Twenty-five days later, the patient had passed little or nothing by rectum. Enemas, however, had always come out through the colostomy. Evidently there

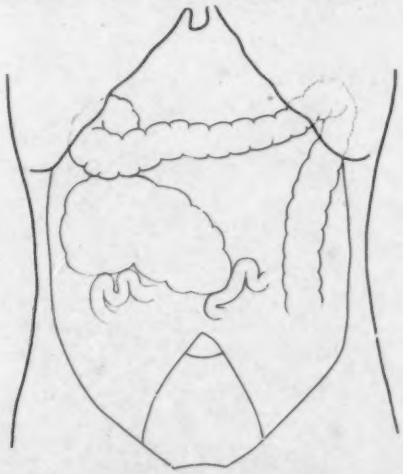

Fig. 6 (Case 2).—Sketch made from roentgenogram taken before operation. Position and enormous dilatation of cecum may be noted. The possibility of a kink in the ascending colon is easily understood. Regurgitation into the small intestine is suggested by the few coils of small intestine shown.

was a valvelike obstruction to the passage of material from above. A barium enema was unsatisfactory. Operation at this time disclosed the condition shown in the accompanying illustration (Fig. 7). The cecum lay in normal position, held down rather firmly by a Jackson's veil. The ascending colon passed upward for perhaps 6 inches (offering an explanation of the collapsed bowel seen outside the distended loop at the first operation) and then turned downward and forward, making a considerable loop. This loop possessed a *fairly long mesentery*. At its distal end, the loop passed back to the hepatic flexure, which like the cecum was firmly fixed. Since there seemed reason to believe that without resection, the kinking (and torsion?) would recur, the cecum, ascending and beginning of the transverse colon were resected, and the ileum anastomosed end to side into the transverse colon.

Four months later, at the time of writing, the patient has picked up in weight and strength. She has had no further "attacks."

COMMENT

The question arises here, as in the second case, whether or not a true torsion has occurred. Certainly, the failure of feces to pass, even when the colostomy had nearly closed, was not due to torsion but to a valvelike kink. Yet one can hardly believe that a kink at both ends of the loop, distal to the collapsed cecum, could have caused, unless sufficient torsion to interfere with the circulation had occurred, such sudden local distention. Even though no twist was demonstrated at the first operation (since the patient's condition contraindicated a satisfactory exploration) it is highly probable that one existed.

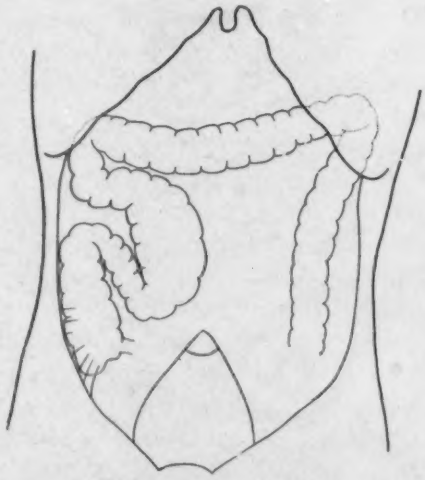

Fig. 7 (Case 3).—Sketch made from operative notes and diagram. The redundant ascending colon and its mesentery are represented as being turned inward. The cecum is fixed by a veil. The hepatic flexure is normally placed and fixed. At operation, the cecum, though proximal to the distended loop, was collapsed. The loop was blocked at both ends.

These three cases represent what has so frequently been described as torsion or volvulus of the right colon. In the first case, the anatomic abnormality, a very free cecum and ascending colon, might never have caused symptoms without the fixation of the ileum and cecum by adhesions, following the patient's acute appendicitis (operated on, by the way, through a median incision). Nevertheless, unusual distention of an unusually mobile ascending colon probably forced the cecum and lower ileum through a bridge of adhesions and so led to the twist. And the tendency to congenital abnormality is further demonstrated by the remarkable loop of descending colon shown in Figure 5. The case falls into Treves' second class.

In the second case, torsion is not actually proved. There will be noted in the sketch made of the preoperative roentgenogram (Fig. 6) a redundancy of the ascending colon. At operation, however, no note was made either as to the presence of a mesentery or of a twist of the bowel. Torsion is possible but unproved, and the condition cannot be considered as falling into any particular classification.

A comparison of the sketch of the ascending colon in the third case (Fig. 7), with the diagrams (Figs. 2 and 3) made from roentgenograms and sketches found in Curschmann's paper, shows that this type of anomaly is quite common. With less complete fixation of the hepatic flexure and cecum, it would doubtless have been harmless. And though the condition has been classified as torsion, it must be admitted that since the bowel was found at operation to lie in its normal direction no twist of the mesentery could possibly have taken place. Any torsion which may then have occurred must have been in the axis of the bowel.

Volvulus and torsion are evidently unsatisfactory terms for such conditions as these, but once established they may well stand. They form a sufficiently definite entity to permit a diagnosis before operating, more especially when there is obtained a long history of colicky attacks evidently linked with the larger intestine by their association with constipation or diarrhea. When such attacks are relieved for long periods by such means as enemas, by the patient's assumption of particular positions, or as in one instance here, by induced vomiting, one may fairly suppose that an intestinal deformity is responsible. And finally, when local distention, whether or not supported by the evidence obtained from roentgen-ray study of the barium enema, can be made out, the actual location of the twist or kink may be inferred.

A series of three cases is perhaps too small from which to draw conclusions as to treatment, but at least it offers evidence that a simple colostomy may be curative. As the initial procedure, a cecostomy is certainly sound. In the absence of actual necrosis of the intestine, it should be sufficient until roentgen-ray study and the behavior of the intestine during closure of the colostomy give some indication as to the future patency of the intestine. In view of the acutely ill condition of many of these patients, any other emergency operation will seldom be practicable. Resection of the malformed or malplaced intestine should undoubtedly be reserved for patients with established necrosis of the bowel and for those whose right colon is clearly incapable of functioning in a normal manner.

# BLOOD NITROGEN ESTIMATIONS IN GENITO-URINARY AND ABDOMINAL CONDITIONS

J. W. VAUGHAN, M.D. AND P. F. MORSE, M.D.
DETROIT

A most complete review of chemical changes in the blood in disease has been presented in a series of articles published in *The Journal of Laboratory and Clinical Medicine* by Victor C. Myers.[1] These articles sum up the present knowledge concerning this most interesting phase of diagnostic and prognostic medicine.

Blood chemistry, as the term is now used, is practically the result of the investigations of American research workers,[2] unaided by the work of any foreign observer, and consequently we can be justly proud of the benefits derived from these investigations. Folin, Benedict, Myers and Van Slyke have been the forerunners in this work, and it is because of their labors that something really new and of practical importance in the every-day practice of medicine has been evolved. As not infrequently happens, a research work intended to be of benefit chiefly to medical practice, has, I believe, proved to be of even more value to the practicing surgeon, and it is only with these facts that we wish to deal.

At the present time, the one important surgical aid has been the estimation of nonprotein nitrogen and the changes observed in this substance in the circulating blood. This is of value chiefly in lesions of the genito-urinary system, and in intestinal obstruction. As Myers has shown, the urea nitrogen estimation is also of value; but the work that has been performed in the laboratory at Harper Hospital shows

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1. Myers, V. C.: Chemical Changes in Blood in Disease, J. Lab. & Clin. M. **5**:343 (March) 1920; ibid. **5**:418 (April) 1920; ibid. **5**:490 (May) 1920; ibid. **5**:640 (July) 1920; ibid. **5**:700 (Aug.) 1920; ibid. **5**:776 (Sept.) 1920; ibid. **6**:17 (Oct.) 1920.

2. Folin, Otto, and Wu, Hsien: J. Biol. Chem. **38**:81 (May) 1919; ibid. **41**:367 (March) 1920. Okada, S.: Amino-Acid Nitrogen in Blood, J. Biol. Chem. **33**:325 (Feb.) 1918. Steinfield, Edward: Bedside Determination of the Blood Urea Nitrogen, J. A. M. A. **75**:473 (Aug. 14) 1920. Hammett, F. S.: J. Biol. Chem. **41**:599 (April) 1920. Pemberton, Ralph, and Foster, G. L.: Studies on the Nitrogen, Urea, Carbon Dioxid Combining Power, Calcium, Total Fat and Cholesterol of the Fasting Blood, Renal Function, Blood Sugar and Sugar Tolerance, Arch. Int. Med. **25**:243 (March) 1920. Gettler, A. O.: Value of Modern Blood Chemistry to the Clinician, J. A. M. A. **71**:2033 (Dec. 21) 1918. Schnabel, T. G.: Blood-Cholesterol in Gastro-Enterological Cases, Am. J. M. Sc. **160**:423 (Sept.) 1920. Chabanier, H., and de Castro Galhardo, A.: Presse med. **28**:653 (Sept. 18) 1920.

that for practical purposes the more easily and rapidly performed estimation of the nonprotein nitrogen furnishes the surgeon with sufficient information for his guidance as to the proper procedure in any given case in which blood chemical findings are desired.

With regard to prostatic obstruction Myers states that "the blood urea has been found to be a very valuable preoperative prognostic test in cases of prostatic obstruction. Cases showing urea nitrogen figures under 20 mg. per 100 c.c. of blood may be regarded as good operative risks as far as the kidneys are concerned. When the urea nitrogen figures are found between 25 and 30, the patient should be operated on with considerable caution and best after a period of preliminary treatment directed to relieve the nitrogen retention. Urea nitrogen figures over 30 mg. are very good evidence of renal involvement and, therefore, afford a rather poor operative prognosis."

When estimating nonprotein nitrogen, the same statement might apply with a change only in the figures given. Any operation in which the nonprotein nitrogen registers more than 60 mg. to 100 c.c. of blood becomes a case in which the risk is increased, and it has become our practice to perform an operation in either one or two stages, using the nonprotein blood nitrogen estimation as the chief guide.

A few words concerning the estimation of the nonprotein blood nitrogen may not be amiss. As Myers points out, the percentage of this form of blood nitrogen is not a constant factor, there being a greater amount present after a meal containing protein than before. For such reasons a finding of from 25 to 30 mg. per 100 c.c. is now estimated as normal, while an increase to 35 or above would be classed as pathologic. We have reviewed about fifty charts and laboratory records representing cases in which a blood nitrogen has been requested by various surgeons at Harper Hospital. These cases have all been abdominal or genito-urinary in character. From these charts, cases have been selected which show something of definite value and which will aid in the proper understanding of this procedure as a diagnostic or prognostic aid. All cases in which a correct diagnosis could not be substantiated, either by subsequent history, subsequent postoperative findings or postmortem examination, have been discarded.

The estimation of the nonprotein nitrogen in any blood sample is made in the following manner, or by some modification of it: To a given amount of blood, sodium tungstate and sulphuric acid are added to precipitate the proteins. Next a micro-Kjeldahl digestion of the nonprotein nitrogenous material is made, and the ammonia is nesslerized and estimated colorimetrically. The technic followed is that described by Folin and Wu.[2] Inasmuch as not more than 5 c.c. of blood

is required for such a test, it can be seen that repeated examinations can be made without hardship or danger to the patient which, in itself, is a very important factor, inasmuch as a study of our cases convinces us that repeated examination at given intervals of four hours or more furnishes valuable information, while single examinations may be so misleading that the surgeon may form decidedly erroneous conclusions.

The following series is composed of thirty-nine cases, which have been selected as stated before. Of these cases, sixteen are genito-urinary and twenty-three represent gastro-intestinal pathologic conditions. The genito-urinary cases may be further divided thus: urethral obstruction, 2; pyonephrosis, 3; renal calculus, 1, and hypertrophy of prostate, 10.

The gastro-intestinal cases may be subdivided thus: intestinal obstruction (high), 5; intestinal obstruction (low), 7; acute gangrenous appendicitis, 5; strangulated hernia (bowel recovery), 2; strangulated hernia (enterostomy or resection), 1; intestinal paresis, 5, and gastric paresis, 1.

In order to present more clearly the points that we desire to elucidate it will be necessary to present certain facts regarding each case in more or less detail.

## REPORT OF CASES

### GROUP I.—GENITO-URINARY

CASE 1.—C. H. N. entered Harper Hospital May 28, 1920, and died June 1, 1920. The diagnosis was urethral obstruction with periurethral extravasation of urine and pus, which extended into the scrotum and through the lower portion of the abdominal wall. Operation consisted solely in multiple incision and drainage throughout the infected area. The onset of symptoms had been five days previously, at which time the patient had first noticed pain during and after micturition, and the scrotum had begun to swell. A postmortem examination showed the scrotum to be 6 inches in diameter, edematous and with many areas of beginning gangrene. The bladder wall was hypertrophic and thickened. There was no gross evidence of cystitis. A large periurethral abscess was found near the posterior portion of the urethra reaching backward and involving the right lobe of the prostate. The pelvic tissues and the tissues around the seminal vesicles were diffusely infiltrated, producing a pelvic phlegmon with pus of the same character as that found in the abdominal wall.

One blood nitrogen estimation made, May 29, 1920, revealed 25 mg. of nonprotein nitrogen per 100 c.c.

*Comment.*—It is evident that this patient succumbed to sepsis following the rather rapid formation of a periurethral abscess. The interesting point to note is that in spite of the fact that urinary obstruction reached a stage when it was so great that most of the urine was passed into the tissues, yet there was apparently not sufficient back pressure to cause any registerable kidney injury.

CASE 2.—Mr. N. K. entered Harper Hospital, July 8, 1920, complaining of frequent urination, necessitating the passage of urine every two hours. There

was considerable difficulty in starting the stream and there was dribbling before and after urination. The duration of pronounced symptoms was four months. The bladder was distended. Examination revealed a urethral stricture, which was dilated.

Blood nitrogen determination, July 9, 1920, revealed 30 mg. per 100 c.c.; uric acid, 5 mg. per 100 c.c.

*Comment.*—This is a second case in which there was evidently retention of urine caused by partial obstruction in the genito-urinary system below the level of the muscular control of bladder outlet. Again there was no evidence of marked renal involvement due to back pressure, although the high uric acid may denote some degree of kidney injury.

Case 3.—E. W. entered Harper Hospital, June 20, 1920. The diagnosis was left pyonephrosis following complete retention of urine for a period of two weeks. The patient had been catheterized entirely during this period. The pathologic condition requiring this procedure was recorded as a stricture of ten years' duration. The blood nitrogen determination, June 20, 1920, read 240 mg. per 100 c.c.; June 23, it was 300 mg. per 100 c.c., and June 24, 600 mg. per 100 c.c. was recorded.

Inasmuch as this was the highest estimation that had ever been encountered, doubt was entertained concerning its accuracy. Consequently a specimen of blood was sent to the Detroit Clinical Laboratory where the result was confirmed. In spite of the extremely high nitrogen estimation, this patient progressed favorably under drainage of the bladder through a catheter, and subsequent blood nitrogen estimations showed a return to normal.

*Comment.*—This is an extremely interesting and instructive case showing that in acute obstructive conditions of the lower genito-urinary tract a remarkably high blood nitrogen finding is not invariably fatal, and consequently cannot be used as a prognostic aid as we had previously hoped. It is also to be noted that a stricture causing complete retention may be followed by grave renal injury, especially in the presence of infection.

GROUP II.—PYONEPHROSIS

Case 4.—Mrs. G. R. entered Harper Hospital, March 28, 1920, and died, April 18, 1920. The diagnosis at the time of entrance was left pyonephrosis. The urine contained from 40 to 50 pus cells to a field.

A cystoscopy performed, April 7, 1920, showed thick pus coming from the left ureter. Microscopic examination of this pus demonstrated the cells to be chiefly polymorphonuclear leukocytes. Cultures were negative and no tubercle bacilli could be found. Roentgen-ray examination failed to reveal any calculus. Urine examination gave an acid urine of 1.015 specific gravity. It contained considerable albumin, no sugar, much pus and many red blood cells.

One hour after cystoscopic examination, the patient suffered a severe chill, which was followed by a rapid pulse and lowered temperature. Vomiting commenced next day, but toward evening the patient appeared much better. The seventh day vomiting began again, and the patient died April 18, 1920.

April 16, 1920, the blood nitrogen showed 300 mg. per 100 c.c.; April 18, 1920, the day of death, 300 mg. per 100 c.c. The blood pressure, April 16, was 155 systolic and 110 diastolic.

*Comment.*—It is unfortunate that no blood nitrogen estimations were recorded before cystoscopy was performed as it is impossible to state, without such knowledge, what evidence there was of right kidney insufficiency before this procedure. However, we believe that we are safe in surmising that cystoscopy

with catheterization of the infected kidney only may not be in all cases the harmless procedure that we usually think it to be. Whether it was this procedure, or some other condition occurring coincidently that was responsible for the fatal outcome cannot be said, but this case shows that when only one kidney is functioning, injury to the good kidney may result without much trauma and may rapidly prove fatal.

To show the value of the blood nitrogen estimation in ascertaining the function of one good kidney, the following case is added because of its similarity.

CASE 5.—Mrs. Z. entered Harper Hospital, Feb. 10, 1920, and was discharged, March 7, 1920. The diagnosis was right pyonephrosis of six years' duration. This case showed pure pus composed chiefly of polymorphonuclear leukocytes coming from the right ureter. There were also a few red blood cells and a trace of albumin. Examination for tuberculosis was negative; staphylococci were present. The urine from the left ureter was negative.

The blood nitrogen taken, Feb. 12, 1920, showed 31 mg. per 100 c.c.

The operation performed, Feb. 14, 1920, furnished these findings: The kidney was found to be so fixed with adhesions and so friable that delivery was impossible. An opening was made through the necrotic kidney substance, and about 1 pint of pus escaped. The kidney substance was next dissected away on all sides, leaving the remnants of the greatly dilated pelvis. This was packed with gauze and its sides sutured to the abdominal wall. Pathologic examination of the tissue removed showed "an old chronic pyonephrosis with complete destruction of the kidney parenchyma. There is a marked overgrowth of lipoidal endothelial cells unusual in simple pyonephrosis and suggestive of gummatous origin." Parenthetically, it might be stated that the routine Wassermann test had proved negative. While at the time of the operation the symptoms were severe, the patient suffering from pus retention with rapid pulse and temperature, yet the convalescence was uneventful, and a urine examination made nine months later, Nov. 1, 1920, showed nothing abnormal.

*Comment.*—This case would seem to show the value of blood nitrogen estimations when seeking information concerning the condition of the functioning kidney after one had been completely destroyed by an infectious process.

GROUP III.—RENAL CALCULUS

CASE 6.—Dr. P. entered Harper Hospital, April 11, 1920. This patient gave a typical history of calculi in both kidneys, which had been confirmed by roentgen-ray examination. While there are several cases of unilateral kidney stone that have showed no change in the blood nitrogen percentage, this is the only case in which the condition was bilateral and in which an estimation had been made.

The phenolsulphonephthalein test showed: left, fifteen minutes, 5 per cent.; thirty minutes, 9 per cent.; right, twenty-three minutes, 5 per cent.

A later test of bladder urine gave these results: fifteen minutes, 12½ per cent.; one hour, 15 per cent., and two hours, 2½ per cent., a total of 30 per cent. in two hours.

The urine contained blood and albumin, but was otherwise negative. Blood nitrogen estimated, April 13, 1920, showed 23 mg. per 100 c.c.

An operation was performed and the recovery was uneventful. This case is reported simply to illustrate the fact that bilateral calculi do not necessarily interfere with kidney function.

GROUP IV.—HYPERTROPHIC PROSTATE

CASE 7.—J. P. entered Harper Hospital, Feb. 9, 1920, and died Feb. 15, 1920. The diagnosis was hypertrophied prostate, and the symptoms showed that the condition had existed for at least five years. For the last week this patient had been catheterized twice daily. There was a cystitis. Two years before presenting himself for operation, his urine was said to have contained 1 per cent. of sugar. The residual urine at the time of operation was from 200 to 250 c.c.

Feb. 12, 1920, the blood nitrogen was 66.6 mg. per 100 c.c.; the blood sugar was 0.12 per cent.

He was operated on Feb. 14, 1920, a one-stage suprapubic prostatectomy being performed. The pathologic report showed an adenomatous hypertrophy of the prostate. No exact record of the amount of urine passed each day after operation was recorded. He died, Feb. 15, 1920, at noon, and on that day 6 ounces of urine were passed.

*Comment.*—This is a case in which a blood nitrogen of 66.6 mg. per 100 c.c. proved fatal in a one-stage operation. This, of course, would suggest active renal impairment before operation was instituted. Parenthetically, it might be noted that our present method of measuring the amount of urine passed in cases in which a suprapubic prostatectomy has been performed is too inaccurate to be of any scientific value. Besides recording the amount passed through drainage tubes, it is necessary to weigh dressings before and after application to estimate the amount of urine excreted. We have perused several charts in which the cause of death was given as uremia when the amount of urine excreted up to the time of death, together with the blood nitrogen estimations, has shown that such a condition was practically impossible, and that the true cause of death was sepsis.

CASE 8.—J. H. entered Harper Hospital, March 22, 1920, and died, April 27, 1920. The history and examination revealed a prostatic obstruction of seven years' duration. Lately it had been necessary to catheterize. No blood nitrogen was recorded before the first operation, which was performed, March 23, 1920. This consisted of a suprapubic drainage performed under local anesthesia. March 27, the blood nitrogen was 66⅔ mg. per 100 c.c.; April 5, it was 52 mg. per 100 c.c.; April 12, it was 60 mg. per 100 c.c., and April 19, it was 46 mg. per 100 c.c. On this date prostatectomy was performed.

April 21, the patient developed a facial erysipelas which proved fatal. April 26, the blood nitrogen registered 75 mg. per 100 c.c. The urine showed a trace of albumin and much pus.

The pathologic report showed a fibrosis of the prostate with a low grade periglandular round-cell infiltration.

*Comment.*—This case illustrates the recovery of kidney injury following suprapubic drainage in prostatic hypertrophy and the advisability of performing a two-stage operation. It is unfortunate that an outside complication made the issue fatal.

CASE 9.—J. B. entered Aug. 2, 1920. A suprapubic puncture had been performed one year before, following progressive prostatic symptoms of three years' duration. He had had to be catheterized ever since the puncture. For the last three days he had had chills and fever. Aug. 3, 1920, a suprapubic puncture was performed. Aug. 5, 1920, the blood nitrogen was 70 mg. per 100 c.c.; creatinin 2 mg.; sugar 0.1 per cent. August 18, a suprapubic prostatectomy was performed.

Sept. 10, 1920, the blood nitrogen was 52 mg. per 100 c.c.; 2.1 creatinin; September 11, blood nitrogen, 86 mg. per 100 c.c.; 2.7 creatinin; September 13, blood nitrogen, 86 mg. per 100 c.c.; 2.7 creatinin; September 25, blood nitrogen, 39 mg. per 100 c.c. The urine was acid, with a specific gravity of 1.022. There was a trace of albumin and considerable pus.

The pathologic report showed marked glandular hypertrophy, with early carcinomatous changes. There was a chronic inflammation of the stroma with increased connective tissue, and prostatic calculi were present.

*Comment.*—The apparent interpretations of the blood nitrogen readings in this case would be a decided interference with kidney function after suprapubic puncture was made. This was again followed by another such increase, which was noted up to twenty-five days after the radical removal which was followed by a normal reading twelve days later.

Case 10.—J. A., aged 76, who entered, June 24, 1920, gave a history of prostatic hypertrophy which had progressed to such an extent that catheterization was frequently necessary. The phenolsulphonephthalein test was: first hour, 20 per cent.; second hour, 25 per cent. The blood pressure was 180 systolic and 100 diastolic. June 28, a suprapubic puncture, with permanent tube drainage, was instituted.

The blood nitrogen, June 24, was 30 mg. per 100 c.c. The blood nitrogen, July 2, was 20 mg. per 100 c.c.

July 20, suprapubic prostatectomy was performed. The patient died, July 18, death being attributed to uremia.

This represents a bad risk in which, according to blood nitrogen readings, the prognosis should have been favorable. The diagnosis of uremia as the cause of death is not in accordance with these findings. Unfortunately, no urinary output estimations were made following the prostatectomy.

Case 11.—C. B. entered Harper Hospital, Feb. 10, 1920, and died Feb. 17, 1920. He gave a history of hypertrophy of the prostate. It had been much more difficult to urinate for the last two weeks, and he had suffered complete retention for the last twenty-four hours. The blood pressure was 140 systolic and 70 diastolic. The white blood count showed 10,000 cells divided into polymorphonuclear, 81 per cent., large mononuclears, 5 per cent.; small mononuclears, 14 per cent. February 10, a suprapubic puncture was performed.

Feb. 11, 1920, the blood nitrogen was 46 mg. per 100 c.c.; February 14, the blood nitrogen was 100 mg. per 100 c.c., and on this date suprapubic drainage was performed; February 17, the blood nitrogen was 150 mg. per 100 c.c.; creatinin, 24. The urine was acid; the specific gravity was 1.022, and it contained neither albumin nor sugar.

*Comment.*—This case shows the postoperative increase in blood nitrogen, which seems to be of rather common occurrence after operative procedures even of simple degree and under local anesthesia.

Case 12.—C. S. entered Harper Hospital, April 25, 1920, and was discharged, May 20, 1920. He gave a history of prostatic hypertrophy of six years' duration, with more acute symptoms for the last six weeks. The blood pressure was 150 systolic and 90 diastolic. The urine was negative except for a large amount of pus. There was 8 ounces of residual urine.

The blood nitrogen, April 26, was 37.5 mg. per 100 c.c. Suprapubic drainage was instituted April 30. Prostatectomy was performed April 30. Recovery was uneventful.

Case 13.—J. A. entered Harper Hospital, April 28, 1920, complaining of symptoms of prostatic hypertrophy. There was 250 c.c. of residual urine. The Wassermann reaction was negative. The blood pressure was 120 systolic and 94 diastolic. Blood nitrogen February 28 was 50 mg. per 100 c.c. A one-stage prostatectomy was performed March 1.

Blood nitrogen, March 11, was 75 mg. per 100 c.c., and March 18, it was 36 mg. per 100 c.c. This patient was periodically irrational from March 5 to March 16, 1920. He developed, during this time, a right epididymitis, which was opened and drained.

*Comment.*—Again we have an illustration of the extra injury to the kidney following operation per se as is shown by the increase in blood nitrogen from 50 to 75 mg.

Case 14.—Mr. S. entered Harper Hospital, May 12, 1920, and died June 10, 1920. He gave a history of hypertrophy of the prostate, with increasing difficulty of urination for ten years. Catheterization was necessary four days before admission. Blood pressure was 130 systolic and 90 diastolic. Suprapubic drainage was performed May 13.

Urine examination, May 14, revealed cloudy acid urine of 1.020 specific gravity. Tests for acetone and diacetic acid were negative. Three subsequent examinations revealed a trace of albumin, and the presence of red blood cells. Otherwise, the urine was negative. Blood nitrogen, May 18, 1920, was 160 mg. per 100 c.c.; May 19, 170 mg. per 100 c.c.; May 21, 170 mg. per 100 c.c.; May 22, 120 mg. per 100 c.c.; May 25, 100 mg. per 100 c.c., and May 28, 66 mg. per 100 c.c. No further examinations were made; but in spite of the apparent decrease, the patient died June 10, 1920, the cause of death being given as uremia.

GROUP IV.—GASTRO-INTESTINAL CASES

Case 15.—C. M., woman, entered Harper Hospital, March 17, 1920, and died March 29, 1920. Operation was performed March 18. Findings were: ulcer of the pylorus and chronic appendicitis. A posterior gastro-enterostomy and appendectomy were performed.

March 18, after anesthesia, the patient vomited three times, the amounts recorded being 3, 4 and 12 ounces. The temperature ranged from 99 to 101.6 F. The pulse varied between 60 and 68. March 19, the patient vomited twice, 6 and 4 ounces. The temperature ran between 101 and 103.4 F.; the pulse between 72 and 100. March 20, no vomiting was recorded. Blood nitrogen determination taken at this time gave 109 mg. per 100 c.c. The temperature ranged between 101 and 102 F.; the pulse from 76 to 80. March 21, there was no vomiting. The temperature ranged from 101.2 to 104 F.; the pulse from 102 to 112. March 22, there was no vomiting; the temperature ranged between 100.8 F. and 103 F.; the pulse from 84 to 96.

No further vomiting was noted on the chart, except a small amount once, March 27. A blood culture taken six hours before death, March 29, gave a growth of pure streptococcus.

Pneumonia was diagnosed, March 22, moist râles being noted. March 24, dulness and bronchial breathing were manifest. Fluid was also suspected, and 160 c.c. was removed from the pleural cavity. The right chest again yielded 600 c.c., March 25, and a roentgenogram, March 29, showed complete consolidation of the right side.

*Comment.*—Unfortunately, no postmortem examination was made, and but one blood nitrogen estimation was obtained. However, we note here a case

in which high obstruction was suspected, and vomiting of slight degree had been present for three days. However, subsequent events proved no obstruction to be present, but possibly a temporary gastric paresis. The blood nitrogen at this period was increased to 109 mg. per 100 c.c.

CASE 16.—Mrs. B. entered Harper Hospital, June 29, 1920, and was discharged, July 21, 1920. Operation was performed June 30. The findings were: pericholecystitis with adhesions around the pylorus and the first portion of the duodenum. A posterior gastro-enterostomy was performed.

The day of the operation the patient vomited ten times, the amounts being small, registering between 1 and 3 ounces. July 1, the patient did not vomit. July 2, she vomited nine times, the amounts being between ½ and 3 ounces. A blood nitrogen estimation was made on this date, the reading being 28 mg. per 100 c.c. The blood pressure was 152 systolic and 65 diastolic. July 3. the patient vomited three times, the amounts being from 2 to 4 ounces. July 4, she vomited once, the amount being 5 ounces; July 5, eight times, with amounts from ½ to 10 ounces. A second blood nitrogen was recorded at this time, the amount being 24 mg. per 100 c.c. July 6, the patient vomited once, the amount being 3 ounces.

July 7, a rather profuse brownish purulent drainage appeared. After which the patient's condition improved immediately. No further gastric disturbances were noted, except that, July 13, the patient vomited three times, from 2 to 3 ounces. She was discharged in good condition July 21.

*Comment.*—We have here a case in which obstruction was suspected because of persistent vomiting. That such was not the case is shown by the subsequent history, the gastric irritation having probably been the result of intraperitoneal hemorrhage associated with a low grade of infection. The blood nitrogen was low at both examinations, and the stomach showed no evidence of over filling as would be found in mechanical obstruction, inasmuch as the amount expelled at any one time was always small.

CASE 17.—Mrs. L. P. entered Harper Hospital, April 18, 1920, and died May 17, 1920. This patient was operated on April 20. The findings were recorded as follows: stomach, transverse colon and small bowel bound together with firm adhesions; the omentum was bound down in such a way that it was difficult to deliver the posterior surface of the stomach. Treatment, however, was posterior gastro-enterostomy.

April 21, the patient vomited twice, 3 ounces each time. April 22, she vomited once, 2 ounces, and gastric lavage yielded 10 ounces. April 23, the patient vomited three times, 2, 2 and 3 ounces. The stomach tube, however, yielded 32 ounces. April 24, no vomiting was registered. April 22, one vomiting spell was noted, the amount being 6 ounces. Gastric lavage yielded 16 ounces. April 26, she vomited once, a small amount. April 28, the patient vomited ½ ounce and the tube yielded 10 ounces. April 29, two vomitings are registered, the amounts being 2 and 60 ounces. April 30, the stomach tube was inserted twice, 35 and 15 ounces being obtained. May 1, she vomited once, 2 ounces; May 2, she vomited once, 3 ounces; but the stomach tube yielded 34 and 15 ounces in two pumpings. May 3, she vomited once, the record being a small amount—the tube gave 9 ounces. May 5, the patient vomited small amounts twice; May 6, twice, 5 and 34 ounces; May 7, three times, 1, 52, and a small amount; May 8, three times, 2, 39 and 1 ounce; May 9, three times, 52, and 28 ounces.

At this time roentgen-ray study was made, which showed an evident duodenal obstruction. A five hour plate showed practically the entire meal retained

in the stomach, and the report made was lower duodenal obstruction. May 10, the patient vomited small amounts, not more than 2 ounces, twice; May 11, five times, from 1 to 4 ounces; May 13, once, 22 ounces.

A blood nitrogen estimation made April 30, ten days after the beginning of obstructive symptoms, gave 50 mg. per 100 c.c. A second estimation, May 13, twenty-one days after obstructive symptoms, gave 33.3 mg. per 100 c c., which might be classed as normal.

May 14, the abdomen was opened, the obstruction relieved and the posterior gastro-enterostomy undone. The patient died May 17.

*Comment.*—We have here a case of definite proved obstruction at the level of the duodenum, in which blood nitrogen readings were not increased. We would conclude from this case that a small amount of jejunum must be above the obstructive lesion before an increase in blood nitrogen can be noted. The only other alternative is that the obstruction was intermittent in character.

Case 18.—W. P. entered June 27, 1920, and was operated on, June 28, 1920. The finding was duodenal ulcer. A posterior gastro-enterostomy was performed. June 30, this patient vomited seven times, the amounts not being recorded. July 4, one attack of vomiting is registered, the amount being 6 ounces. July 7, the patient vomited 12 ounces; July 10, a "large amount" is given, and July 11, he vomited twice, and the stomach was twice emptied by means of a tube. No accurate vomitus record was made, but roentgen-ray examination, July 16, revealed practically complete gastric retention at the end of twenty-four hours.

The blood nitrogen, July 12, after four days of vomiting, was 46 mg. per 100 c.c. The blood pressure was 95 systolic and 60 diastolic.

July 19, the abdomen was reopened and an acute kink in the efferent loop was discovered, which was caused by omental adhesions to the abdominal wound. The patient died July 21.

*Comment.*—Again we have a case in which the obstruction was evidently highly situated without an increase in the noncoagulable nitrogen resulting.

Case 19.—Mrs. G. B. entered Aug. 10, 1920. This patient had been operated on in May, 1920, for a pelvic abscess, which had been drained. She now complained of epigastric pain and nausea. Laparotomy was performed August 11, the finding being charted as a pericholecystitis, with a partial obstruction of the second portion of the duodenum. The adhesions causing this were severed, infolded and so sutured as to relieve the obstruction.

Postanesthetic vomiting was represented by four attacks, each being of a small amount. August 12, the patient vomited eight times, the amount ranging from a small amount to 6 ounces. August 13, she vomited five times, amounts varying from 3 to 19 ounces. She was also disturbed by hiccupping. August 14, she vomited twice, the amounts being ½ and 2 ounces.

A blood nitrogen estimation at this time gave 41.5 mg. per 100 c.c.

August 15, two attacks of vomiting were noted, a small amount and 5 ounces. August 17, she vomited once, 8 ounces. August 21, she vomited once. Recovery was uneventful thereafter.

*Comment.*—This represents a case in which the operator evidently suspected high obstruction, which was neither borne out by the nitrogen reading nor by the subsequent history.

CASE 20.—Mr. H. entered Harper Hospital, Oct. 5, 1920, and was discharged, Nov. 10, 1920. A posterior gastro-enterostomy and an appendectomy were performed October 13. The findings were: duodenal ulcer and chronic appendicitis. The ulcer was on the posterior wall of the duodenum just below the pylorus. There were numerous adhesions between the omentum, duodenum and gallbladder. Postanesthetic vomiting consisted of 3 ounces at one period, October 13.

The patient progressed favorably until October 21, when he vomited twice. The register states that the first was a large amount, the second 32 ounces. October 22, the patient vomited four times, 30, 18, 12 and 30 ounces. October 23, two vomiting periods were noted, 32 and 18 ounces. October 24, the patient vomited five times, the amounts being 23, 3, 7, 16 and 12 ounces. The abdomen was re-opened at 8:00 p. m. that night.

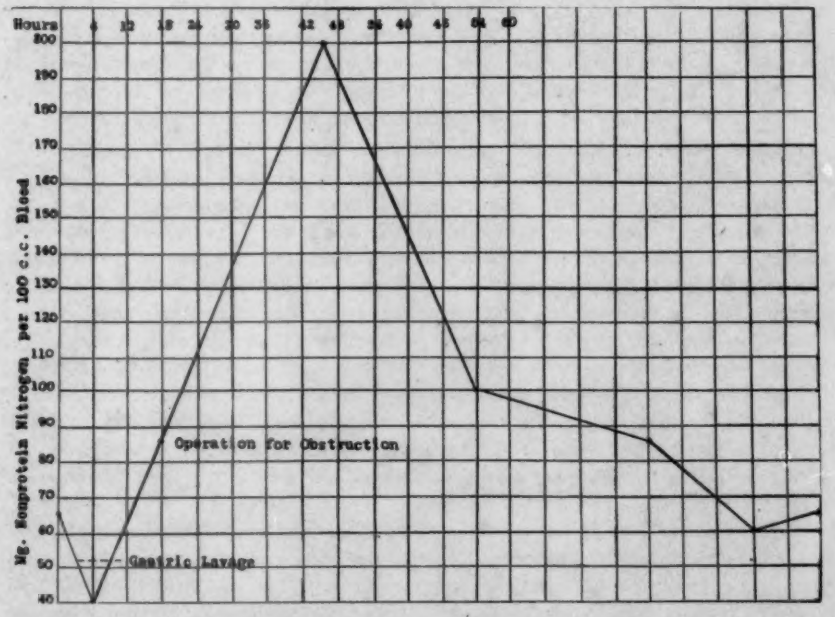


Fig. 1 (Case 20).—Increase in blood nonprotein nitrogen in a case of high obstruction.

Blood nitrogen estimations were commenced at 10:15 a. m. October 23, and the first reading showed 67 mg. per 100 c.c.; at 4:15 p. m. of the same date 40 mg. per 100 c.c. were noted. Gastric lavage had been given between.

October 24, at 11:45 a. m. the blood nitrogen was 86 mg. per 100 c.c. and, as stated above, the patient was re-operated on at 8:00 p. m. that evening. The second operation disclosed an omental adhesion to the anterior abdominal wall along the previously made incision. After dividing these adhesions, the duodenum was exposed and the jejunum was found to be distended for a distance of 18 inches below the gastro-enterostomy. At this point the intestine was collapsed, a definite ring being found at the collapsed point. The ring had evidently been caused by the adhesions which had been freed. The jejunum filled into the collapsed part while under observation. The wound was closed.

The next day, October 25, gastric lavage yielded 26 ounces. There was no more vomiting except once, October 27, the amount being 30 ounces. The further recovery was uneventful and the patient when seen, December 10, reported a gain of 30 pounds, with no gastric symptoms.

Further blood nitrogen estimations made after the second operation proved of interest: 2 p. m., Oct. 25, 1920, gave 200 mg. per 100 c.c.; October 26, 100 mg. were reported; October 27, 86 mg. were present; 9 a. m., October 28, the amount was 60 mg., and October 30, 67 mg. per 100 c.c. were recorded.

Thus we can see that the nonprotein blood nitrogen showed a decided increase after the obstruction had been relieved, and that more than forty-eight hours elapsed before the percentage had receded to a point equal to what it was before the second operation was performed.

*Comment.*—This case shows the blood nitrogen increase noted in a high obstruction situated 18 inches below Treitz's ligament. It differs from Cases 15 and 16 in that a short portion of the absorptive jejunum was above the obstruction. It also illustrates the necessity of performing repeated examinations, and drawing conclusions from the upward trend of the nonprotein blood nitrogen. Placing reliance upon a single reading is likely to be unreliable. For this reason a curve of the increase has been made in this case (Chart 1).

Case 21.—Mr. L. entered Harper Hospital, Nov. 23 and died Nov. 30, 1920. The diagnosis upon entrance was carcinoma of the rectosigmoidal juncture, with obstructive symptoms. Operation was performed under local anesthesia, November 24. This consisted solely in preparing the transverse colon for a colostomy. Examination of the liver at this time showed that metastasis was present. November 26, the colostomy was opened. This apparently never functioned. Content of the large intestine could be washed up from below, but no fecal matter could be washed from above. Symptoms of obstruction continued until death, which occurred at 10:45 p. m. November 30.

The first blood nitrogen estimation was obtained at 9 a. m., November 29. It gave: 86 mg. per 100 c.c.; at 6 p. m. the same date 74.2 mg. per 100 c.c. were noted. At 2:00 p. m., the date of death, 100 mg. per 100 c.c. were obtained.

In view of the continued increasing blood nitrogen curve, the postmortem findings are of interest.

The abdominal cavity contained neither fluid nor gas. The intestines and stomach were markedly distended. At the juncture of the sigmoid and rectum there was a large mass about 4 by 4 by 4 inches. This was firmly adherent to the bladder anteriorly, while posteriorly it was attached to the tissues over the sacrum. It did not involve any other portion of the large intestine. The descending colon was filled with impacted feces. The colostomy opening was situated at the midportion of the transverse colon. In the appendix area there were found a number of adhesions, one of which involved the cecum, and fastened it to the abdominal wall about the midaxillary line, and 2 cm. above the crest of the ileum. This caused an acute kink in the intestine, above which point the intestines were found to be distended. Below this point there was no distention. About one half of the appendix was found to be present. No other findings of importance were noted, except the liver metastasis previously noted, and an involvement of the retroperitoneal lymph glands. Microscopic findings confirmed the diagnosis of adenocarcinoma with metastasis.

*Comment.*—This case is interesting because of the fact that a partial obstruction caused by tumor growth was evidently changed into a complete obstruction caused by a twisting of the intestine at the site of adhesions following an old appendicitis. The terminal obstruction situated at the ileocecal valve was

above the colostomy opening. The entire length of the small intestine was above this lesion. Along with these findings we have a progressively increasing blood nitrogen curve. The reading, however, did not reach as high a level as in many other cases, being only 100 mg. per 100 c.c. a few hours before death.

CASE 22.—Mr. J. S. was admitted to Harper Hospital November 6, and died Nov. 9, 1920. On entering the hospital this patient gave a history of persistent vomiting together with no bowel movement for a period of eight days. The abdomen was noticeably distended, and the patient was markedly dehydrated. He stated that he had had to use a laxative nightly for the last nine or ten years. Vomiting began October 29. There was a decided odor of acetone in the expired air. The temperature was 98 F., and the pulse 100. The diagnosis was intestinal obstruction.

November 6, the date of entrance, the abdomen was opened through a right gridiron incision. The small bowel was markedly distended, the terminal ileum was brought out and an enterostomy performed. Blood nitrogen taken upon this date, November 6, gave 240 mg. per 100 c.c. The patient continued to vomit and received no benefit. The blood nitrogen, November 8, was 300 mg. per 100 c.c. The patent died the next day.

Postmortem findings showed the omentum and intestine to be adherent around the enterostomy opening. There was no free fluid in the abdomen. Upon separating the omentum from the coils of the intestine, an acute angulation of the ileum was found at the enterostomy wound. The proximal loop of the intestine was turned sharply downward completely shutting off its lumen, and was filled with a large quantity of fluid and gas. The portion of the proximal loop immediately adjacent to the enterostomy wound was entirely in the pelvis and dragged down upon the enterostomy keeping it tightly closed. The tube, which had been inserted into the lumen of the intestine was in the distal and not in the proximal intestine. About 12 inches proximal to the ileocecal valve was found the original site of the organic obstruction. The body of the appendix was over the pelvic brim and reached well down into the pelvis where it was adherent by many old adhesions to a tangled mass of ileum and sigmoid. Distal to this the intestine was collapsed, while in a proximal direction it was hugely dilated and filled with fluid. Otherwise, the abdomen was negative.

*Comment.*—Again we have the attempted relief of a bowel obstruction, followed immediately by a more complete obstruction. The blood nitrogen readings again show an increase, the total being much higher than in the previous case.

CASE 23.—Mrs. W. entered the Harper Hospital February 27, and died March 19, 1920. March 3, an operation was performed for the relief of a postoperative ventral hernia. This consisted of dissecting free adherent bowel in a large sac, and it was deemed necessary to resect the small intestine for a distance of 1 foot. An end-to-end anastomosis was performed.

March 13, the patient vomited once, the amount being 3 ounces. The temperature reached 104.2 F., the pulse 104 and respiration 22. No more vomiting was noted until March 17. The temperature ranged from 100 to 106 F., the pulse from 102 to 124. March 17, the patient vomited twice, at 4:45 p. m., 2 ounces; at 9:00 p. m., a small amount.

The blood nitrogen at 12:15 p. m., March 17, was 150 mg. per 100 c.c. At 7:20 p. m. it read 171 mg., and at 10 a. m., March 18, it registered 184 mg. per 100 c.c. The question was one of infection or obstruction. Vomiting had been small in amount.

March 17, at 10 p. m. the abdomen was reopened. The small bowel was found to be dilated to 3 inches. Tubes were inserted at two levels and fluid and gas evacuated. The patient died March 19 at 1 p. m.

No postmortem was made, but the secondary operative findings bore out the supposition of small intestine obstruction.

CASE 24.—Mrs. E. entered Harper Hospital, May 17 and was discharged June 19, 1920. May 18, operation consisting of the removal of internal and external hemorrhoids, dilatation and curettage, appendectomy, partial excision of the right ovary, left oophorectomy and shortening of the round ligaments, was performed.

Postanesthetic vomiting, May 18, consisted of 5 ounces, accomplished in one period. May 19, the patient belched considerable gas. The temperature average was 99.8 F., the pulse 112. Blood pressure was 135 systolic and 85 diastolic. She vomited once, the amount being 5 ounces. An enema was effectual for gas and a small amount of clear fluid.

The blood nitrogen at this time, taken at 2 p. m., gave 75 mg. per 100 c.c.

May 20, the belching of gas and abdominal pain continued. No further vomiting was registered, and May 21, a small bowel movement was recorded, and the patient progressed favorably thereafter. The blood nitrogen, May 21, registered 27 mg. per 100 c.c.

*Comment.*—In this case there was some degree of gastric and intestinal paralysis from which the patient quickly recovered. Here we note a decided increase in the blood nitrogen estimation, which was quickly followed by a decrease.

CASE 25.—Mrs. F. entered Harper Hospital, June 27, 1920. June 28, a panhysterectomy was performed with the removal of the upper portion of the vagina and a section of bladder for carcinoma. Gallstones were noted, but not disturbed because of the amount of work performed.

June 28, the temperature ranged from 98 to 101.2 F., the pulse from 80 to 116. June 29, the temperature ranged from 100.4 to 101.8 F., the pulse from 116 to 128. Abdominal distention was marked, and an enema furnished no results.

June 30, the temperature ranged from 99 to 99.4 F., the pulse from 104 to 128. The patient was markedly distended and vomited twice, the amount being ½ ounce each time. Four enemas were given and five injections of pituitary extract without effect until that night when considerable flatus was expelled.

The blood nitrogen at 10:20 a. m., June 30, was 100 mg. per 100 c.c. At 2 p. m. it was again 100, and at 9 p. m. it registered 133 mg. per 100 c.c. July 1, the temperature ranged from 98.8 to 100.2 F., the pulse from 112 to 128. She vomited twice in amounts of 3 ounces and ½ ounce. Gastric lavage yielded 12 ounces. No result was obtained by means of an enema. A blood nitrogen taken at 11 a. m., however, showed a decrease to 67 mg. per 100 c.c. July 2, the temperature ranged from 98.2 to 98.8 F., the pulse from 108 to 116. The stomach tube yielded only 1 ounce. Two enemas were slightly effectual. After this, recovery was uneventful. Blood nitrogen, July 5, was 60 mg. per 100 c.c. The patient was discharged in good condition, July 15, 1920.

*Comment.*—We note here another case of rather severe intestinal paresis accompanied by a high blood nitrogen reading. One case, as cited above, of complete fatal obstruction did not give as high a reading as is noted here. However, a downward drop of 66 mg. was here noted in fourteen hours, which in our opinion classified this case as intestinal paresis instead of true obstruction.

CASE 26.—Miss H. N. entered, July 20, 1920, with a diagnosis of gangrenous appendicitis. Blood count revealed: leukocytes, 13,000; differential: polymorphonuclears, 85 per cent.; small mononuclears, 6 per cent.; large mononuclears 9 per cent. The temperature was 101 F., the pulse 96 at the time of entrance. A gangrenous appendix was removed July 20, and the wound closed tight. July 21, the patient vomited twice, the amount each time being 4 ounces. Gastric lavage gave a light green return, the amount not being registered. There was marked distention. The temperature varied between 100.2 and 101.4 F., the pulse between 96 and 156.

July 22, she vomited small amounts twice. Lavage gave a dark brown return. The blood pressure was 116 systolic and 85 diastolic. The lowest temperature was 101, the highest 102.8 F., while the pulse ranged around 150. She died at 11:30 p. m. The nonprotein nitrogen estimated upon the date of death showed 67 mg. per 100 c.c. The cause of death was evidently an overwhelming infection.

*Comment.*—This represents a case of severe sepsis in which there was some degree of intestinal paralysis. The blood nitrogen reading was somewhat increased, which agrees with our findings in other cases.

CASE 27.—T. S. entered Harper Hospital, April 9, 1920, complaining of pain and tenderness in the lower abdomen. The pulse was 96, the temperature 99 F. The total leukocyte count gave 21,000, of which 95 per cent. were polymorphonuclears. The operative findings were seropurulent fluid in free cavity, and a perforated gangrenous appendix. This was removed and drainage inserted. Recovery was uneventful.

Nonprotein blood nitrogen obtained, April 10, the day after operation, showed 35 mg. per 100 c.c. The urine showed a trace of albumin, but otherwise it was negative.

*Comment.*—This is a second case of general peritonitis following a gangrenous appendix, which differed from the previous in the practical absence of any gastro-intestinal symptoms. Here the blood nitrogen reading might be classed as normal.

CASE 27.—W. W. entered, May 10, 1920. The diagnosis was gangrenous appendicitis with general peritonitis. Operative findings were: purulent fluid free in peritoneal cavity, 3½-inch retrocecal appendix, gangrenous at distal end with a perforation one half inch from the tip. Appendectomy with drainage was performed. Daily after operation the patient had one or more vomiting spells of small amount. There was considerable distention and pain. On the thirteenth day after operation, a blood nitrogen reading gave 22 mg. per 100 c.c. Enemas and cathartics were but slightly effectual for feces and flatus. May 29, the wound was reopened and a large walled off abscess was found in the rectal fossa. This was drained and recovery was uneventful thereafter.

*Comment.*—This was a case of possible obstruction, not borne out by the blood nitrogen findings, which proved to be not obstructive, but abscess formation.

CASE 28.—Mrs. M entered Harper Hospital, May 2, and died May 30, 1920. She was operated on, May 26, the operation consisting in the removal of a large intraligamentous leiomyofibroma of the left side. It measured approximately 9 by 4 by 5 inches.

May 26, she vomited once, the amount being 4 ounces. May 27, hiccups were noted, but no vomiting. May 28, the stomach was emptied twice, and an enema was effectual for flatus and light brown fluid. A second enema was not

effectual. The temperature ranged from 100.8 to 103.6 F.; the pulse from 81 to 128. May 29, gastric lavage was repeated. An enema was followed by some flatus with shreds of mucus and a few particles of feces. The stomach was washed a second time and castor oil administered through the tube. A second enema gave no results, but shortly afterward two bowel movements, consisting of a large amount of feces and flatus, were noted. The temperature ranged from 103.8 to 105.8 F., the pulse from 93 to 130. The blood nitrogen taken at 11 a. m. gave 60 mg. per 100 c.c.; repeated at 9:30 a. m. the next morning, May 30, the reading was 66 mg. per 100 c.c. The patient died at 2:30 p. m., May 30.

*Comment.*—No postmortem was obtained, but the fact that good bowel movements were obtained after the administration of castor oil would lead us to interpret this case as one of sepsis in which there was some degree of intestinal paralysis. The blood nitrogen increase would accord with this.

Case 29.—Mrs. S. entered Harper Hospital, June 29, 1920. The diagnosis was strangulated left femoral hernia, vomiting, pain and irreducible tumor of twenty-five hours' duration. Blood pressure was 140 systolic and 90 diastolic. Blood nitrogen 24 mg. per 100 c.c. Operative findings were: a large sac with a small neck containing strangulated omentum, which was discolored and excised. Search disclosed a discolored loop of small bowel about 5 inches in length, which had slipped back into the abdominal cavity when the sac was opened. This recovered its appearance within two minutes and was replaced.

*Comment.*—This represents a case of strangulated hernia showing no increase in blood nitrogen. Not having seen this case ourselves, it is difficult of interpretation. If the symptoms were caused by strangulated omentum alone, the findings would have been in accord with our other experiences; but if actual intestinal obstruction existed, the low nitrogen is difficult of interpretation. However, it is more than probable that the bowel above the small strangulated area was not dilated to any degree as such should have been noted in the chart if it had been the case. It is to be hoped that the findings in another similar case entering the hospital will be recorded more minutely, and that more nitrogen estimations will be made.

Case 30.—B. R. entered Harper Hospital, August 6, and was discharged Aug. 25, 1920. The diagnosis was strangulated right inguinal hernia. Pain and vomiting began two days before. Attempts at reduction had failed.

Operation was performed August 7, and a nonprotein blood nitrogen estimation was made the same day. This registered 86 mg. per 100 c.c. The operative findings were: some free fluid in the abdominal cavity with a loop of small bowel in the right inguinal ring. Release of this loop was followed by bowel recovery.

The patient vomited twice August 8, after which recovery was uneventful.

*Comment.*—Strangulated bowel hernia of forty-eight hours' duration was followed by a decided increase in nonprotein blood nitrogen.

Case 31.—Mrs. H. P. entered Harper Hospital, May 28, 1920. May 29, an appendectomy, left salpingo-oophorectomy, excision and invagination of Meckel's diverticulum were performed. Proctocele was repaired with reconstruction of the sphincter muscle.

May 30 the temperature registered between 99.2 and 100 F., with a pulse rate between 96 and 120. May 31, the temperature was between 98.6 and 100 F., with a pulse rate of 100 to 122. There was considerable nausea and vomiting.

June 1, blood nitrogen was 20 mg. per 100 c.c.; June 2, it was 17 mg. per 100 c.c.

The patient showed improvement June 1. No more nausea or vomiting were recorded, and she was discharged June 11, 1920.

*Comment.*—This was a case in which the possibility of an obstruction was entertained owing to the clinical symptoms. It was borne out neither by the blood nitrogen finding nor by the subsequent history.

CASE 32.—Mrs. A. entered Harper Hospital, May 17, and was discharged June 9, 1920. May 10, a right salpingo-oophorectomy, left salpingo-oophorectomy, supravaginal hysterectomy because of right tubo-ovarian abscess, multiple myoma of uterus, left hydrosalpinx and cystic left ovary surrounded by dense adhesions, were performed.

May 10 postanesthetic vomiting was registered six times, varying in amount from 1 to 5 ounces. The temperature ranged from 97 to 100.2 F., the pulse from 90 to 118.

There was no vomiting the second day. May 11, the temperature ranged from 98.4 to 99.4 F., the pulse varied between 118 and 120. May 12, the patient was nauseated, but she did not vomit. Temperature varied from 97.4 to 99.2 F., the pulse between 100 and 112.

May 13, she vomited once, amount 2 ounces. Temperature varied from 98.6 to 100.2 F., the pulse from 96 to 100. May 14, there was no vomiting. May 15, she vomited once, 4 ounces. May 16 she was nauseated, but did not vomit. May 17, she was nauseated, vomited once, a small amount. May 18, she was nauseated, vomited once, small amount; May 19, nauseated, vomited three times, 7 to 10 ounces. May 20, she vomited twice, small amounts. May 21, there was no vomiing. May 22, she vomited three times, small amount to 8 ounces. May 23, she vomited eight times, 1 to 8 ounces. May 24, she again vomited eight times, small amounts; gastric lavage was instituted. May 25, she vomited twice, 2 ounces.

Blood nitrogen taken at this date showed 42 mg. per 100 c.c. After this she vomited once, May 30, amount 7 ounces, after which recovery was uneventful.

*Comment.*—After fifteen days of gastric distress, a blood nitrogen estimation showed that no obstruction was present. This was confirmed by the subsequent history.

CASE 33.—Mrs. S. M., colored, aged 26, entered Harper Hospital, Dec. 7, 1920. She was operated on December 10. The findings were: retrocecal appendix, retroverted uterus, small tumor mass 2 cm. in diameter on right uterine cornu and left cystic ovary. The abdomen was otherwise negative. Operative treatment consisted of appendectomy, removal of a tumor on the uterine cornu, and reduplication of round ligaments.

The postoperative course showed nothing unusual until the third day, when the pulse rate increased to between 112 and 128, with normal temperature. The patient vomited once, 10 ounces, the vomitus consisting of a foul, greenish brown fluid. Gastric lavage was performed once—amount not noted. December 13, the fourth day after operation, gastric lavage was performed twice. The pulse ranged from 100 to 122, the temperature was normal. An alum enema was unsuccessful.

December 14, the pulse varied between 96 and 112, the temperature rate between 96 and 101 F. Three enemas were given, two of which were effectual for flatus. No vomiting was recorded. However, the patient was extremely restless. She was distended, and her condition generally was unsatisfactory.

December 15, the first blood nitrogen was recorded. This showed 133 mg. per 100 c.c. The blood pressure was 108 systolic and 78 diastolic, and a total and differential leukocyte count was normal. No further vomiting had been recorded; but the abdomen remained distended and firm in spite of the fact that small amounts of flatus had been expelled. Because of the high blood nitrogen reading, together with the clinical picture presented, the patient was taken to the operating room, and a second laparotomy performed. A right rectus incision was made. There was a moderate amount of serous fluid free in the cavity. The small bowel was markedly distended and dark blue in color. A definite band was found to encircle the ileum near the ileocecal valve. Separation of this was followed by the passage of gas and fluid into the distal portion of the bowel. An enterostomy was performed just above the obstructive area in the ileum.

No more vomiting was recorded until December 23 when the patient vomited once, ½ ounce. Here, December 26, a notation says, "very little fecal matter drains through the enterostomy now," and evidently another obstructive lesion was feared. December 25, she vomited once, 6 ounces. December 27, she vomited twice, 6 and 2 ounces, and Jan. 1, 1921, once, immediately after partaking of breakfast. Death ensued at 6.55 p. m. January 1.

While the patient's condition was bad almost continually following the operation for obstruction necessitating frequent resort to hypodermoclysis, yet improvement was marked so far as the obstructive symptoms manifested. The enterostomy worked freely and the abdomen was much softer and less distended within twenty-four hours.

December 18 it was noted that the general condition was much improved. Again the chart states, December 19, that the condition was improved, as was also borne out by the pulse rate and temperature.

December 26, the wound opened, exposing about 3 feet of small intestine. In this area three small holes, about 1 cm. in diameter, were noted. As stated above, another obstructive lesion was feared at this time. Together with this possibility, was now a picture of sepsis.

Of chief interest to us, however, is the blood nitrogen curve during and following the obstructive lesion. As stated above, December 15, at 11:45 a. m., the date of the second operation, which occurred at 12 midday, 133 mg. per 100 c.c. were recorded; December 15, at 4 p. m., 130 mg. per 100 c.c.; December 16, at 2 p. m., 75 mg. per 100 c.c.; December 17, at 1 p. m., 32.5 mg. per 100 c.c.; December 17, at 11 p. m., 30 mg. per 100 c.c.; December 18, at 9 a. m., 26 mg. per 100 c.c.; December 23, at 9 a. m., the day that vomiting recurred, 100 mg. per 100 c.c.

*Comment.*—In this case we note an immediate fall in the blood nitrogen reading following the relief of an obstructive lesion. This does not accord with our findings in other cases, notably in Case 20, in which there was a temporary high increase in blood nitrogen following relief of obstruction.

## CONCLUSIONS

A study of the series of cases noted above leads to certain more or less definite conclusions. Many other cases have been recorded since this tabulation was made, but a review of the latter cases does not alter in any way the conclusions that have been drawn; therefore, a further addition of case reports would be valueless.

In general, it can be stated that a low blood nitrogen in prostatic obstruction may be used as a guide as to the advisability of a one-stage or a two-stage operation. However, other factors than this must be taken into consideration, and it is my belief that the cause of death in many cases, given as uremia following prostatectomy, is erroneous in the extreme, it being due to a low grade infection solely. In corroboration of this point, we cite one more case which was not included in the series heretofore reported:

CASE 34.—Mr. J. P., aged 78 entered Harper Hospital, Dec. 23, 1920, with the diagnosis: hypertrophied prostate with secondary infection. The symptoms were: dribbling, pain on urination, frequent urination, every ten to fifteen minutes, residual urine 250 c.c. Examination revealed a prostate, 4 inches across by 3½ inches in height—smooth and firm. December 23, suprapubic drainage was instituted under local anesthesia together with a slight amount of gas. A drainage tube 1 inch in diameter was inserted into the bladder. The

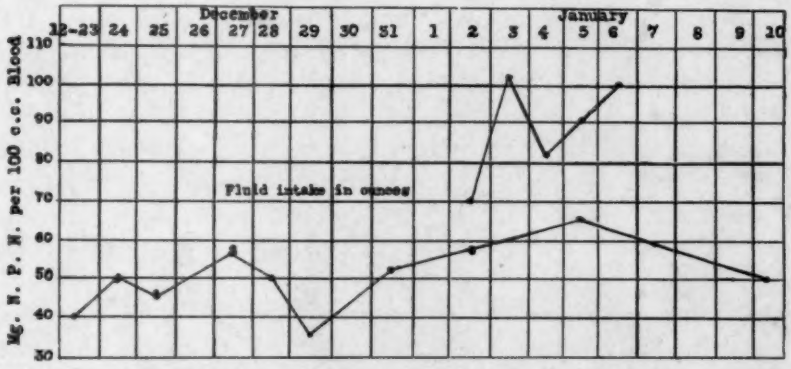


Fig. 2 (Case 34).—Blood nonprotein nitrogen estimations in a case of hypertrophy of the prostate.

postoperative course was unusually stormy. The patient was irrational for many weeks. He was very restless, would attempt to get out of bed and would sleep for periods of from fifteen to thirty minutes at a time.

December 31, he developed a right sided parotitis. After this, his breathing became labored and he slept more or less constantly. The temperature at this time registered as high as 101.6 F.; the pulse 106 and of poor quality. January 3, the patient developed a left parotitis. January 6, this had cleared up and the general condition had improved. He was brighter and had periods when he was more rational. Thus, we had a clinical picture simulating that of uremia, and yet the cause of this syndrome, in our opinion, was solely an infection.

Before operation, Dec. 23, 1920, the blood nitrogen was 40 mg. per 100 c.c.; December 24, it read 50 mg. per 100 c.c.; December 25, 46 mg. per 100 c.c.; December 27, 57 mg. per 100 c.c.; December 28, 50 mg. per 100 c.c.; December 29, 33.4 mg. per 100 c.c.; December 31, 52 mg. per 100 c.c.; January 3, 60 mg. per 100 c.c.; January 5, 67 mg per 100 c.c., and January 10, 50 mg. per 100 c c.

Thus, we had a fluctuating blood nitrogen finding which, however, never reached a high level. The patient left the hospital, January 11, and the prostate has subsequently been removed, but his mental condition is even yet far from satisfactory.

A persistent high blood nitrogen estimation is, I believe, a sign of grave prognosis in genito-urinary surgical conditions, but one single high reading is of but little significance. Indeed, a single, or even two or three, estimations, may be of but little value. It is the daily or more frequently estimated curve that is of prognostic value, and any other method of interpretation may lead to erroneous conclusions.

When we come to consider gastro-intestinal lesions, this fact, that conclusions should be drawn, not from a single estimation, but from the curve formed by repeated estimations, is even more forcibly impressed on us.

In postoperative cases we are frequently unable to differentiate between intestinal paresis and true obstruction. Both may have a high blood nitrogen estimation, but the curve goes upward in true obstruction, and tends to fall when such a lesion is not present.

It is my belief that the chief value we have derived from this work is that it has caused us to operate in cases of true intestinal obstruction earlier than we would have otherwise done, thus materially reducing our mortality in this condition. It must be remembered, however, that high duodenal obstruction, above the absorptive area of the intestine, gives no increase in the blood nitrogen estimation even when complete. It is now our practice, when intestinal obstruction below this area is suspected, to have blood nitrogen estimations made from every four to six hours and to place considerable reliance on the curve plotted by these successive readings. If it increases rapidly, the abdomen is immediately opened. If there is no increase, or a decrease is noted, it is safe to temporize.

# FUNCTION IN RELATION TO TRANSPLANTATION OF BONE*

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During recent years the subject of transplantation of bone has occupied an important place in the literature and has been the text of many practical as well as experimental papers. It is agreed and accepted by the majority of investigators that a live piece of bone from the same individual, with its periosteum and endosteum intact, is the most satisfactory tissue and offers the greatest possibility of successful transplantation. But there are many problems connected with bone transplantation, both from the scientific and the practical standpoint, that are unsolved and disputed. One of these, which will be considered in this paper, is that which is concerned with the part played by function and its influence over the viability of transplanted bone.

If we direct our attention to the physiology of the animal body many instances of the influence of function may be seen. In general, with a maximum of function, there is an increase in size, in strength, in activity and vitality, while with a minimum of function, there is a diminution in size, in strength, in activity and vitality. Thus we see in certain glandular structures, as, for instance, the thymus, a gradual increase in size and activity up to its maximum of function and then a decrease in size to almost complete disappearance with the diminution of function. Again with a more easily comprehensible tissue like muscle, there is the increase in size, strength, activity and vitality with greater use and function of this particular tissue up to the maximum for the individual and a corresponding decrease in these properties with a lessening and minimum of function. In the case of bone, we are not accustomed to associate function so closely with its developmental and growing changes; but by analyzing the various processes, one can see the relationship to the changes in this tissue. Thus, as bone develops from its embryologic structure, either from connective tissue or cartilage, it changes from a soft elastic and pliable tissue to a firm, hard, strong and somewhat brittle substance. This change in structure is coincident with the demands of function, as in the embryo and in early life, the only functional call upon the new cartilaginous tissue is the maintenance of form. As movements become more active and greater strength is required, an osteoid tissue is formed, and finally with the next demand for support, there is need for a stronger tissue and the mineral constituents are added, changing the osteoid to osseous

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tissue. With further elaboration and more localized functional demands at a definite place on a particular bone, there take place, in response to such demand, certain changes within the bone itself, and osseous tissue is deposited or formed at a particular place with such definite mechanical and architectural arrangement as is required best to fulfill such needs. This is best exemplified in the structure of the neck and upper portion of the shaft of the femur, where one sees on cross section a system of girders and trusses so mechanically arranged as to offer the greatest strength to the components of force acting upon this part of the bone. One can also see greater density and thickness of the cortex at the point of greatest strain exerted by muscle tension.

When we come to consider the part played by function in relation to the vitality and increase in size of a bone graft, the problem becomes somewhat more complicated. By analogy it would seem that certain of these physiologic demands should prove to be an influencing factor in the case of the transplanted bone; that is, it would be one of the determining factors in the persistence, the growth and the development of the bone graft. The quantitative rôle played by function has been variously stated by different authors without proof or reason for such assertions. My views on this particular point, as well as on transplanted bone in general, can be best expressed by quoting from a previous article:[1]

> From these experiments and the results in general on transplanted bone, the following conclusion is offered regarding the fate of bone transplantation. Although each part of the transplanted bone possesses the power to regenerate independently and without the aid of neighboring bone, this autonomous newly formed tissue does not possess that property which is necessary for a continued existence, and it will ultimately entirely disappear. Some additional stimulus is needed and such conditions are only obtained when the transplanted bone is in contact with normal growing bone. Therefore, when there is failure of such connection the transplanted bone at first shows evidence of regeneration, but if a sufficient time is allowed to elapse, it will ultimately entirely disappear. However, if it is united with the cut surface of normal bone, it will continue to live because certain necessary additional stimuli and new elements will be supplied by the host. It is possible that certain chemical or physiologic stimuli are supplied by the living intact bone after which the regenerated bone on account of these additional factors is able to persist permanently. Undoubtedly, some definite osseous elements from the bone of the host invade the transplant and either replace the temporary bone or give to it certain requisites for its perpetuation. *Although function may play a factor in the development of bone, it is not of prime importance in determining the permanency of that tissue.* The different opinions of the various investigators are in part due to the failure to allow sufficient time to elapse before drawing final conclusions, as well as to take into account the influence of different environmental conditions on the transplant from both young and old animals.

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1. Haas, S. L.: The Transplantation of the Articular End of Bone, Including the Epiphyseal Cartilage Line, Surg., Gynec. & Obst. **23**:301 (Sept.) 1916.

Thus, it is seen that function is considered as playing a very minor part; but such deductions were arrived at more by exclusion than by evidence. It is hoped that the investigation herewith reported will throw some light upon this interesting problem and graphically express the effects of this peculiar force called function.

It is also to be noted that the view is maintained that it is absolutely essential that the transplant be in contact with the freshly cut surface of normal bone in order to be permanently successful. In order to

Fig. 1 (Exper. 2, duration fifty-five days, young dog).—*A*, reimplanted phalanx; *B*, reimplanted metatarsal; *A'*, transplanted phalanx, and *B'*, transplanted metacarpal. When the reimplanted phalanx *A* is compared with the transplanted phalanx *A'* that was removed from the muscles of the back at the end of fifty-five days, the transplanted phalanx shows more evidence of degeneration than the reimplanted bone, being less dense, smaller, and more irregular in outline. When the reimplanted metatarsal *B* is compared with the transplanted metacarpal *B'*, the same relative difference between these bones as between the other two is seen. There is an osseous union of the reimplanted with the adjoining bones at the base. The reimplanted bones which are subjected to the normal stimulation of function show less evidence of degeneration than the transplanted bones which are removed from this normal stimulus.

determine the rôle played by function independently of all other factors, it becomes necessary to eliminate the possibility of contact with denuded bone and prevent such stimulating influences as ingrowth of new bone. Thus a set of experiments have been devised which it

is believed offer the conditions necessary to solve this problem. The metacarpal or metatarsal bones are easily manipulated and afford very suitable bones for the purposes of transplantation, but in their removal, the periosteum and cortex as well as the cortex of the neighboring bones are liable to be injured, thereby offering the possibility of ingrowth of bone. The proximal phalanx, however, can be removed quite easily without injuring its periosteum or the adjoining bones, thereby offering no possibility for the ingrowth of bone. It could then be transplanted to the muscles of the back or reimplanted in its original position. In order to insure the possibility of normal function, it is considered as being desirable to preserve the joints at either end and this is accomplished by removing the entire metacarpal or metatarsal bone, the intact joint between it and the first phalanx, and one half of the second phalanx with the intact joint between the two phalanges. In such a transplant, there is an entire first phalanx with both its joints intact and its osseous elements separated at either end by two articular cartilages from the osseous elements of adjoining bones. Furthermore, the adjoining bones are themselves part of the transplant. With such a group forming a transplant, there is practically no chance for ingrowth of bone into the first phalanx unless there is a destruction of the articular cartilage of the phalanx as well as that of the neighboring bones; and as articular cartilage is quite transplantable and does not tend to degenerate, it offers an ideal barrier against ingrowing bone.

If this group of bones be removed from an animal's foot and then reimplanted in the same place, they would be subjected to their normal stimulation of function. If a similar group of bones be transplanted to the muscles of the back, they would not be subjected to the stimulation of normal function. The first phalanges, when compared to each other at the termination of the experiment, would show the influence of function on the graft, because both transplants would have been subjected to the same amount of trauma in their removal, to the same destruction of their blood supply and would differ only in the bed which they occupy and the function to which they are subjected. It is considered that any difference in the two bones can, therefore, be ascribed to the difference in function, and with this for a working basis, the following set of experiments was performed.

### OPERATIVE PROCEDURE

All of the operations were performed upon dogs of various ages. In every instance a general anesthetic was used and precautions were taken in the after-care to prevent any suffering. The operations were performed with the usual aseptic technic, in this manner. An incision was made on the dorsum of the foot through skin and subcutaneous

tissues so as to expose the metatarsal or metacarpal bones with their corresponding phalanges. The selected bones were carefully removed so as to cause as little trauma as possible and treated according to the plan of the experiment. The wounds were then closed in layers and a sterile dressing applied, which was held in place by adhesive plaster and, when necessary, by a plaster-of-Paris bandage. The animal was allowed to use the foot from the start, and as soon as healing was complete, all dressings were removed. At the conclusion of the experiment, roentgenograms were taken of the feet and the bones that were transplanted to the muscles of the back. In addition to this, pieces of the bones were fixed for microscopic study.

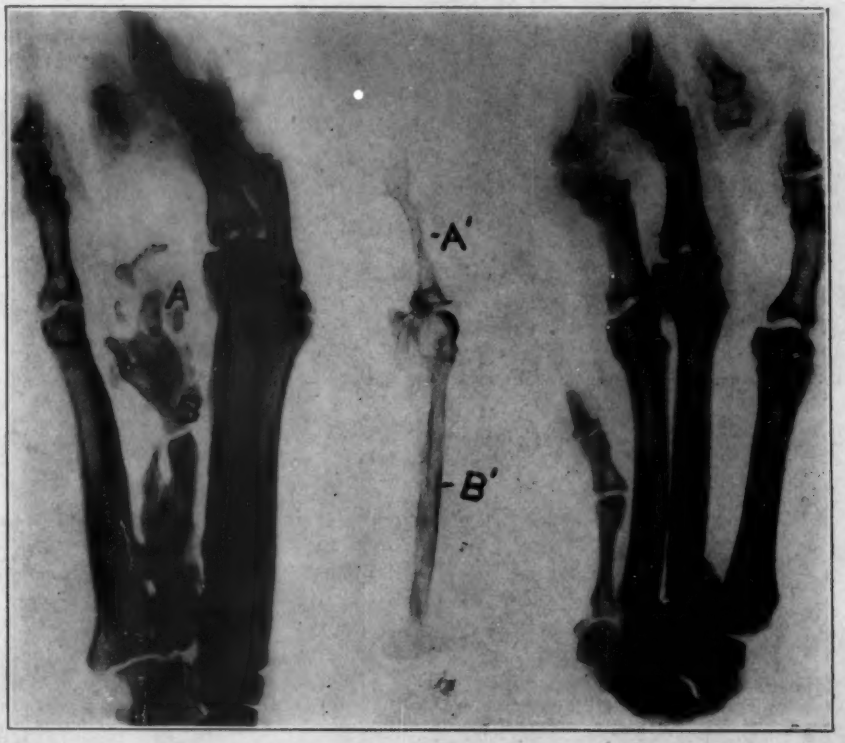


Fig. 2 (Exper. 3, duration sixty-nine days, young animal).—*A* and *B*, infected reimplanted metatarsal and phalanx; *A'*, transplanted phalanx and *B'*, transplanted metacarpal. Because of the infection, the reimplanted bones are unsatisfactory for comparison. The transplanted phalanx *A'*, which was removed from the muscles of the back at the end of sixty-nine days, shows marked absorption thinning, and rarefaction of the cortex. The transplanted metacarpal bone *B'* shows similar changes when compared to the normal phalanx. The destructive processes are more marked than those in the previous experiment (Fig. 1).

## REPORT OF EXPERIMENTS

EXPERIMENT 1 (Duration, forty-eight days; reference numbers, 50-52, 51-52).—(*a*) The entire third metacarpal bone of the left fore foot was removed and transplanted to the muscles on the right side of the back.

(*b*) The entire second metacarpal bone of the fore foot was removed and immediately replaced in its normal position.

FINDINGS, FORTY-EIGHT DAYS

*Gross.*—(*a*) The bone was found embedded in the muscles of the back. The epiphyseal cartilage plate is white and quite distinct. The marrow space of the epiphysis is occupied by cancellous bone. The remainder of the marrow cavity is smaller than normal and contains pale marrow. The transplant is smaller than the normal bone and appears to be undergoing atrophic changes.

*Microscopic.*—(*a*) The articular cartilage is of fairly normal structure. The marrow of the epiphysis is in part replaced by fibrous tissue, the remainder being of fairly normal appearance. The trabeculae of the epiphysis show evidence of degeneration in their centers and regeneration about the periphery. The marrow of the diaphysis is for the greater part replaced by fibrous tissue. The cortex shows some lacunar absorption on its surface which is quite different from the deposition of new bone seen in the case of the normal bone.

*Gross.*—(*b*) The reimplanted bone appears more like the normal bone than the bone transplanted to the back. The marrow cavity is narrow, and the marrow elements appear paler and less in amount than normal

*Microscopic.*—(*b*) The articular cartilage is practically normal. The marrow is for the greater part replaced by fibrous tissue. The trabeculae show degeneration at the center and newly formed bone on the periphery. The marrow of the diaphysis is likewise replaced by fibrous tissue, and the trabeculae show the same changes as in the epiphysis. The cortical bone shows degeneration within its outer layer and a new deposit of bone on the periphery.

COMMENT

In this experiment, the metacarpal was transplanted alone, and, therefore, the criticism that there is an ingrowth from the neighboring bones may be made. However, the experiment is reported to show the early changes that take place in transplanted bones. There is an early degeneration with a subsequent regeneration of at least a portion of the bone. The bone transplanted to the back shows a more marked degeneration and early evidence of absorption.

EXPERIMENT 2 (Duration, fifty-five days; reference number 132, 80-133, 80, young dog).—(*a*) The entire fourth metacarpal bone with its adjoining phalanx was removed from the left fore foot and transplanted to the muscles of the back on the right side of the spine.

(*b*) The entire third metatarsal bone with its adjoining first phalanx and one half of the second phalanx of the right hind foot was removed and replaced in its normal position.

FINDINGS, FIFTY-FIVE DAYS

*Gross.*—(*a*) The bones transplanted to the muscles of the back are found encapsulated in dense fibrous tissue. They are much smaller than the normal bones. On longitudinal section, the marrow of the metacarpal is seen to be very scant while that of the phalanx is fairly normal. The roentgenogram (Fig. 1) shows the marked absorption of the metacarpal bone as well as of the phalanx. The joint surfaces appear normal.

*Microscopic.*—(*a*) The phalanx, on section, shows an almost normal articular cartilage. The marrow elements of the proximal end have been partially replaced by fibrous tissue. The epiphyseal cartilage plate has almost entirely disappeared. The cortex is very thin and irregular showing considerable evidence of erosion and absorption.

*Gross.*—(*b*) The reimplanted bones are found well healed in their bed. The bones are shorter and broader than the normal bones. On longitudinal section the marrow of the phalanx is found to be practically normal. The metatarsal bone shows marked thickening of the articular cartilage with a widening of the epiphysis. The cancellous bone is of variable color. The epiphyseal cartilage plate is undergoing calcification at its center. The cortex is very thin and irregular showing considerable evidence of erosion and absorption.

The roentgenogram (Fig. 1) shows the transplanted bones shorter than normal. The phalanx is of normal breadth and its structure is normal, except that the marrow space is not so distinct. The metatarsal appears normal and one sees a union with the adjoining bones at the base.

*Microscopic.*—(*b*) Examination reveals a partial degeneration of the articular cartilage. The marrow elements have been replaced by fibrous tissue. The trabeculae possess well stained nuclei which are larger than normal and have somewhat the appearance of regenerated nuclei. The cortex shows marked signs of degeneration and in places is very thin.

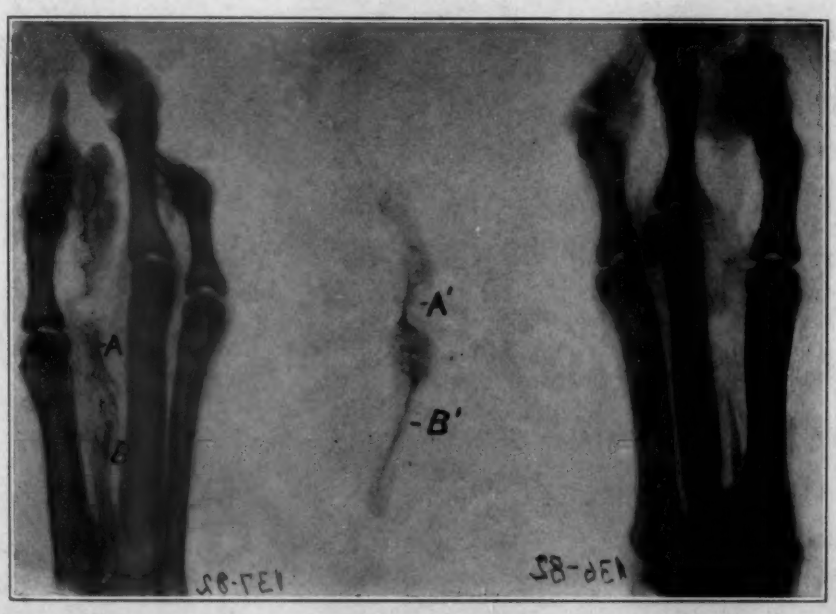


Fig. 3 (Exper. 4, duration 273 days, very young animal).—*A*, reimplanted phalanx; *B*, reimplanted metacarpal bone; *A'*, transplanted phalanx, and *B'*, transplanted metacarpal bone removed from muscles of back. There is a marked absorption both in the reimplanted and in the transplanted bones. On close study, the degeneration is found to be greater in the transplanted bone than in the reimplanted bone. This difference is more evident in the gross specimen than in the roentgenogram.

### COMPARATIVE RESULTS

A comparison of the reimplanted with the transplanted bones reveals evidence of greater absorption and degeneration in the case of the bone transplanted to the back.

EXPERIMENT 3 (Duration, sixty-nine days; reference numbers 146, 87-148, 87).—(*a*) The entire third metacarpal bone of the left fore foot with its corresponding first phalanx and one half of the second phalanx was removed and reimplanted in its normal position.

(*b*) The entire fourth metatarsal bone of the right hind foot with its corresponding first phalanx and one half of the second phalanx was removed and reimplanted in its normal position.

FINDINGS, SIXTY-NINE DAYS

*Gross.*—(*a*) The metacarpal bone and phalanx show considerable evidence of atrophy. The cortex of the metacarpal is irregular. The marrow cavity is likewise irregular. The end of the bone is penetrated by fibrous tissue. The phalanx is likewise found to have an irregular cortex and the marrow cavity is almost absent. The roentgenogram (Fig. 2) shows the evidence of absorption with the thinning and atrophy of osseous elements.

*Microscopic.*—(*a*) This examination was unsatisfactory because of the poor staining. However, one could distinguish the evidence of degeneration and absorption.

*Gross.*—(*b*) Because of infection with resulting osteomyelitis, the bones were partially destroyed. The results of this experiment are therefore altered. The metacarpal that remains is irregular, but rather eburnated. The phalanx has practically disappeared.

*Microscopic.*—(*b*) The cortex and trabeculae show poorly stained nuclei while those of the marrow stain fairly well.

EXPERIMENT 4 (Duration, 273 days; reference numbers 136, 82-137, 82, young dog).—(*a*) The entire metacarpal of the right fore foot with its corresponding first phalanx and one half of the second phalanx was removed and transplanted to the muscles of the back. The periosteum was stripped off the metacarpal.

(*b*) The entire third metacarpal bone of the left hind foot with the entire first phalanx and one half of the second phalanx was removed. The periosteum was removed from the metatarsal and then the entire specimen was reimplanted in its original position.

FINDINGS, TWO HUNDRED AND SEVENTY-THREE DAYS

*Gross.*—(*a*) The specimen removed from the muscles of the back shows a complete disappearance of one half of the second phalanx. The first phalanx is atrophied to a sliver-like mass and bends like cartilaginous tissue. The metacarpal is likewise atrophied but not to such an extent as the other bones. The roentgenogram (Fig. 3) shows that the phalanx and metacarpal bone have undergone atrophy. When compared with the reimplanted bones, the atrophy is found to be greater than that which has occurred in those bones.

*Microscopic.*—(*a*) The transplanted bone shows an extensive degeneration throughout the various parts of the articular cartilage. There are in places clusters of cells suggesting an attempt at regeneration. The marrow has been replaced by fatty tissue which is quite vascular. The osseous tissue has lost the greater part of its nuclear staining and everywhere shows evidence of degeneration.

*Gross.*—(*b*) The reimplanted bones show marked evidence of atrophy but not to the extent of the bones that were transplanted to the back. The joints are partially destroyed. The roentgenogram (Fig. 3) shows the absorption of the bones, which when compared with the bones transplanted to the back is less marked. The joints appear quite indistinct.

*Microscopic.*—(*b*) There is degeneration of the articular cartilage but of a lesser degree than in the case of the transplanted bones. The marrow is replaced by fibrous and fatty tissue. The osseous tissue is undergoing degen-

eration as evidenced by the poor staining of the nuclei. In places the nuclei stain fairly well, showing that the degeneration is not so complete as in the case of the bone transplanted to the back.

EXPERIMENT 5 (Duration, 493 days; reference numbers 141, 84-143, 84, old dog).—(*a*) The entire fourth metacarpal bone of the left fore foot with its corresponding first phalanx and one half of the second phalanx was removed and the entire specimen transplanted to the muscles along the left side of the spine.

(*b*) The entire fourth metatarsal bone of the right hind foot with its corresponding first phalanx and one half of the second phalanx was removed and the entire mass reimplanted in its original position.

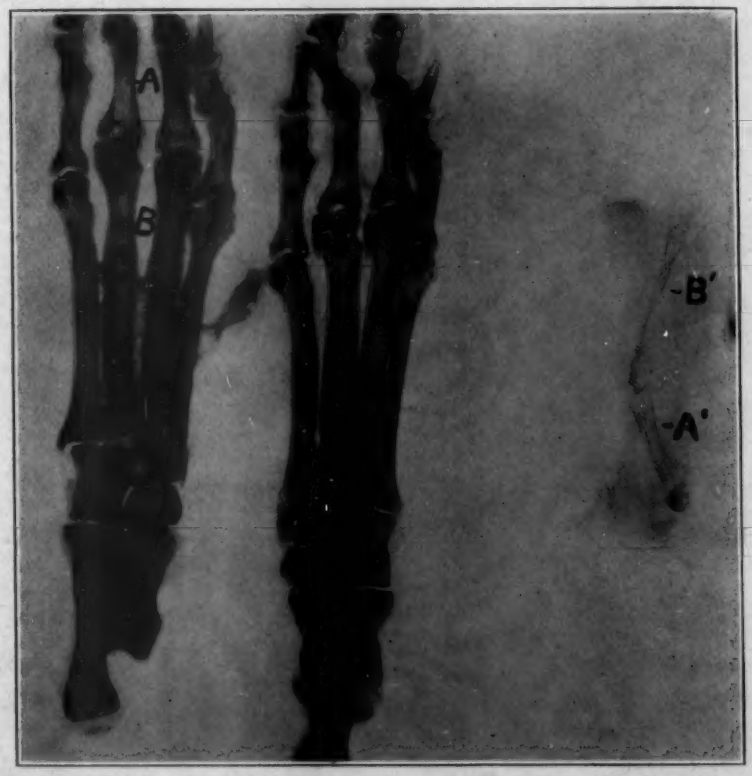


Fig. 4 (Exper. 5, duration 493 days, old animal).—*A*, reimplanted phalanx; *B*, reimplanted metatarsal; *A'*, transplanted phalanx, and *B'*, transplanted metacarpal (relative position is reversed in illustration). There is a very marked difference between the reimplanted and the transplanted bones. The reimplanted bones show very little evidence of absorption in contradistinction to the extensive changes in the transplanted bone as noticed when *A* is compared with *A'* and *B* with *B'*. The ingrowth of bone from the adjoining bones into the reimplanted metatarsal *B* may be noted. The degenerative changes are much less extensive in the reimplanted bones than in the previous experiment (Fig. 3). The degenerative changes are much less extensive and slower in the older animals.

FINDINGS, FOUR HUNDRED AND NINETY-THREE DAYS

*Gross.*—(*a*) The transplant to the back was found encapsulated in the muscles of the back. The bones have undergone marked atrophy and can be easily bent. On section, the cortex is found to be reduced to the thickness of a sheet of paper. The marrow that remains is yellow. The roentgenogram (Fig. 4) shows marked

atrophy and absorption of the bones. It is much more marked than that which has taken place in the reimplanted bones.

*Microscopic.*—(*a*) The small fragment of the transplant shows that the articular cartilage still possesses stainable nuclei. The osseous tissue shows well stained nuclei in places. One is surprised at the absence of the usual picture seen in bone absorption. This might be due to a cessation of absorption at this time or to a different mode of absorption from that which usually takes place. The nuclei of some of the trabeculae stain; but they are for the greater part stainless and degenerated.

*Gross.*—(*b*) The reimplanted bones are found healed in their normal position. The joints show some restriction in motion. The metatarsal has fused with the adjoining bones at its base. On section both the metatarsal bone and phalanx are found to have lost the fresh glistening appearance of the marrow and are much drier than normally. The roentgenogram (Fig. 4) shows the absorption of the bones as is evidenced by the irregular outline and rarefaction. The marrow cavity has an irregular outline. The fusion of the metatarsal at its base is well shown.

*Microscopic.*—(*b*) The articular cartilage stains poorly, especially on the surface. The trabeculae are thicker than normal and in the greater part there is failure of nuclear stain. The marrow elements are absent. The cortex is thinner than normal and its nuclei stain very poorly.

### COMMENT

In this experiment, the extensive absorption of the inactive transplant to the back is very strikingly shown. The reimplant which is subjected to the normal functional stimulus has undergone a much less extensive and slower absorption. It appears that it too had been permanently damaged and that if new osseous tissue ingrowth did not take place it ultimately would have undergone further absorption.

EXPERIMENT 6 (Duration, three years; reference numbers 139, 83-140, 83, old dog).—(a) The entire third metacarpal of the left fore foot with its corresponding first phalanx and one half of the second phalanx was removed and the entire specimen transplanted to the muscles of the back. The periosteum was stripped from the diaphysis of the metacarpal.

(*b*) The entire fourth metacarpal of the left fore foot with the entire first phalanx and one half of the second phalanx was removed and the entire specimen reimplanted in its original position.

### FINDINGS, THREE YEARS

*Gross.*—(*a*) This animal died during my absence. As there was no specimen obtained from the muscles of the back, it is assumed that it had entirely disappeared. This is very probable in view of the fact that in the previous experiment after the elapse of 493 days, a period less than half that of the present experiment, only a very small remnant of the original transplant remained.

*Gross.*—(*b*) The reimplanted bones are found healed in the position in which they were placed at the time of the operation. The metacarpophalangeal joint is occupied by fibrous tissue. The phalanx on external examination appears fairly normal, although somewhat smaller than normal. On longitudinal section, the phalanx is found to be more eburnated than normal, and the marrow cavity is occupied by cancellous bone containing some marrow elements. The metacarpal is also smaller than normal, somewhat eburnated and has a small mar-

row cavity. The roentgenogram (Fig. 5) shows the phalanx smaller than normal with an irregular outline. A small marrow space is seen at its distal end. The metacarpal bone is smaller than normal with an irregular outline and marrow cavity.

*Microscopic.*—(*b*) The phalanx has a smooth articular cartilage at its distal end. A portion of the articular cartilage possesses nuclei which stain, but have an irregular arrangement. In other parts of the cartilage, there is a lack of nuclear staining. The trabeculae of the distal end are thicker than normal with fairly well stained nuclei except at the centers. Very few marrow cells are noticed. The cortical bone of the diaphysis stains fairly well, although in places there is an absence of nuclear staining. The periosteum is rather

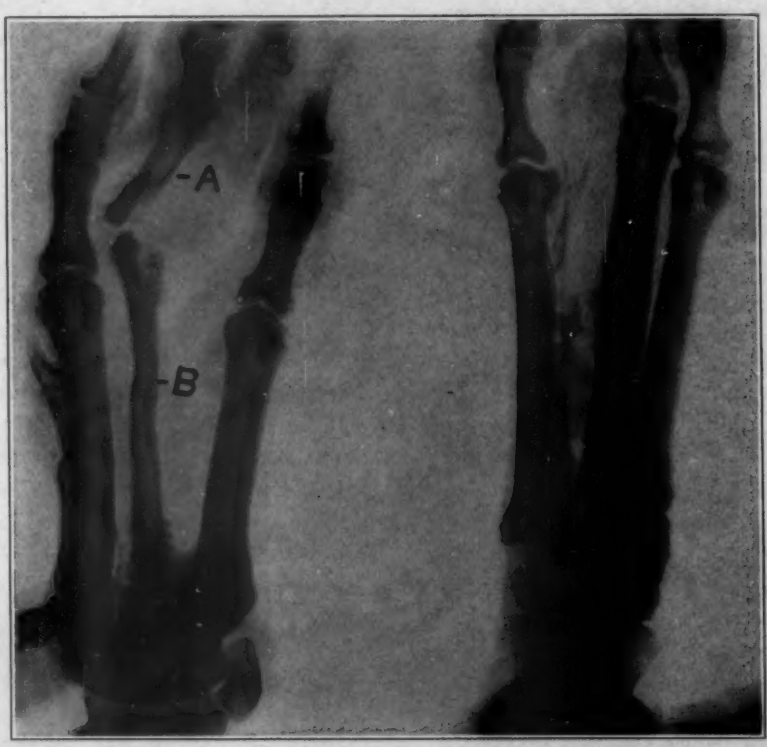


Fig. 5 (Exper. 6, duration three years, old animal).—*A*, reimplanted phalanx; *B*, reimplanted metacarpal. The phalanx and metatarsal that were transplanted to the muscles of the back were not recovered, and it is assumed that they were entirely absorbed. The reimplanted phalanx *A* has undergone moderately extensive degenerative changes. When compared with the adjoining normal phalanges, it is noticed that it is about one-half the width, much less dense, and more irregular in outline. The changes in the metacarpal *B* are of a similar nature. Thus it is noticed that the reimplanted bones which are subjected to the normal functional stimuli undergo much less extensive and slower degenerative changes than the transplanted bones to the muscles of the back where such stimulation is lacking.

indefinite, and in places there is no differentiation between it and the surrounding fibrous tissue. There is no definite evidence of erosion, but the appearance is that of a slow degenerative process. The proximal articular cartilage has disappeared, being replaced by fibrous tissue. The metacarpal bone shows a complete erosion of the distal articular cartilage with a replacement by fibrous tissue. The trabeculae appear denser than normal, but the

nuclei stain better than those of the phalanx. The nuclei of the cortex stains better than in the case of the phalanx. As with the phalanx, the periosteum is indistinct, blending closely with the surrounding fibrous tissue. Although there is a definite degenerative process going on in the metacarpal, it is of a lesser degree than in the phalanx and the bone appears more viable.

### COMMENT

The findings in this experiment are similar to those of the previous experiment. The bones transplanted to the back have undergone a complete disappearance while those reimplanted have persisted. Thus it appears that the stimulation of function exerts a decided influence over the fate of bone. It is to be noted that, in spite of the persistence of the reimplant, it shows evidence of a slow absorption, and it would be interesting to know whether the process would continue to the eventual complete disappearance of the bone.

### GENERAL COMMENT

Before coming to any definite conclusions or deductions from the results of these experiments, it is essential that we carefully analyze the findings in order that due consideration be given to the various factors that may influence and play a contributing part in the complex changes that have taken place in the transplanted bones.

Study of the bones that were transplanted to the muscles of the back reveals a slow progressive degeneration. The extent of the degeneration is proportional to the lapse of time and is practically complete at the end of three years. The osseous tissue in this case is entirely removed from the normal stimulation of function.

The bones that were reimplanted in their normal position underwent a much slower degenerative process, and even after three years at least one half of the bone persisted. The osseous tissue in this case was subjected to the normal functional stimulation.

The question naturally arises as to whether the difference in the behavior of the two sets of grafts can be ascribed entirely to the difference in the functional forces acting on the osseous tissue. There may be other conditions that play a rôle and are responsible at least for some of the differences in the behavior of the two. In the first place, it is noticed that there is a difference in the bed occupied by the two bones, the one in the back being in a muscular bed, while that in the foot occupies a bed consisting of scant fibrous tissue. It is possible that there are more active phagocytic and osteoclastic elements in the muscular tissue, but from the microscopic picture one can see but little difference in the two instances. Another factor to be considered is the difference in the vascularity about the grafts. There is a greater vascularity of the muscular tissue of the back than there is of the fibrous tissue of the foot. An argument may be offered favorable to either side, using vascularity as its basis. It may be asserted that with a richer blood supply there is a greater opportunity for destructive

processes to take place, and it is believed that such an element must be given some consideration. On the other hand, it has been asserted by many that a penetration of blood vessel is of prime importance in determining the viability of a transplanted piece of bone. If such were the case, then it would be natural to expect that the grafts in the back would persist for a longer period on account of the greater blood supply. Granting that these factors may exert some influence over the difference in the behavior of the two sets of grafts, it is quite evident that their importance is small when compared with the undisputed and very evident difference in the functional stimulation to which the osseous tissue is subjected in the two sets of experiments. It, therefore, seems justifiable to ascribe a very important rôle to function in determining the viability of a transplanted piece of bone.

It is noticed that some of the grafts exhibited less evidence of absorption even at a later period than those that were removed earlier. It is possible that the explanation for this apparent discrepancy in the results depends upon the variation in the age of the animals. It has previously been determined[1] that transplants removed from older animals were more resistant to absorption than those from younger animals; and in the particular instances in these experiments in which there was a variation in the degree of degeneration such a difference in age was found to exist. The reasons for the fact that the grafts from older animals show greater resistance to absorption is most likely due to their greater density, to the difference in their chemical constituents, to the thicker and firmer periosteum and to the larger size of the transplant.

It has been maintained that a graft in order to persist permanently must be in contact with the cut surface of live bone in order that there might be an ingrowth of osseous tissue and that certain chemical and physical elements might be supplied by the bone of the host. In these experiments, the phalanx that was reimplanted and was without contact with such denuded bone persisted, even after three years, although one cannot say definitely whether this bone would permanently resist the destructive processes. From microscopic study, there is some evidence that a slow progressive degenerative process is going on in this tissue which still possesses live bone cells. It is possible that after the lapse of a very long period of time there takes place within this osseous tissue, which shows both constructive and destructive processes, a reestablishment of the growth equilibrium and vascularization, under the normal functional stimulation, and that the graft is thereby able permanently to survive. On the other hand, if the destructive forces are superior, the bone will ultimately be absorbed.

From the clinical standpoint, the question arises as to the advisability of using free osseous transplants. Such free transplants have

been utilized in the reconstruction of a lost thumb or other digit. It would be interesting to know the results of these operations after the lapse of a number of years in order to know whether the transplants live permanently. However, should the graft entirely disappear, enough stability would probably be offered by the resultant fibrous tissue to insure sufficient support to the new member to justify this type of operation.

From the practical standpoint the establishment of early function is advisable in order to assist in insuring the success of the operation involving the transplantation of bone. The institution of this early function should not be undertaken if it jeopardizes the osseous union of the graft with the host, a condition which is of prime importance, and, in general, absolutely essential in order to insure the success of the operation.

## CONCLUSION

1. Function exerts a definite influence over the viability of a transplanted bone.

2. Free bone transplants when subjected to the stimulation of normal function undergo a slower degeneration than similar transplants that are not under such functional influence.

3. Bone transplants from old animals are more resistant to absorptive and degenerative processes than those from young animals.

4. From the practical standpoint the institution of function at the earliest possible moment is advisable in order to aid in insuring the success of the operation involving the transplantation of bone; but this early function should not be established if it jeopardizes the possibility of the bony union between the transplant and the host, a condition that is essential and of prime importance.

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# THE COMPOSITION OF APPENDICEAL CONCRETIONS*

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Concretions of varying appearance, density and structure are often found in the human appendix, both with and without inflammatory changes in the organ itself. Owen T. Williams [1] has made a particular study of these, calling attention to the fact that the appendix seldom contains fecal material, and that the usual appendiceal stones are not fecal concretions but concentrically laminated concretions, often larger than the lumen of the appendix between the stone and the cecum, and therefore presumably formed by secretion from the wall of the appendix. According to him, the typical appendix concretion is almost white, with a smooth cut surface resembling soap, whereas fecal concretions are pigmented and have a greasy appearance. Like the intestinal sand, they contain fats soluble in ether and soaps insoluble in ether. He analyzed three appendix concretions, and found material soluble in ether to the amount of 14.97, 16.2 and 7.1 per cent., respectively. The fatty acids of soaps insoluble in ether amounted to 15.6, 2.1 and 1.2 per cent., and the amount of calcium was 3.3, 3.6, and 3.2 per cent. He asserts that the calcium exists as soaps, but presents no chemical evidence to establish this opinion.

Bertha Anthony [2] reported the microscopic study of a large number of normal and diseased appendixes, and found material staining pink with scarlet R, sometimes associated with material staining black with silver nitrate, which she also interprets as proving the presence of calcium soaps. As one of us [3] has pointed out, however, silver nitrate does not stain calcium, but indicates the presence of phosphates or chlorids. If a calcium-containing material stains with silver nitrate it usually means the presence of calcium phosphate, and not the presence of calcium soaps. Therefore, the work of Williams and Anthony furnishes no evidence that calcium soaps are formed in the wall of the appendix, or that such soaps are excreted into the lumen of the appendix to form concretions. Nevertheless, it is highly probable that calcium

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*From the Otho S. A. Sprague Memorial Institute, and the Department of Pathology, University of Chicago.

1. Williams, Owen T.: Biochem. J. **2**:395, 1907; Brit. M. J., July 27, 1907.
2. Anthony, Bertha: J. M. Res. **25**:359, 1911.
3. Wells, H. Gideon, J. M. Res. **14**:491, 1906.

soaps are present in the appendix, since fats as well as fat-splitting enzymes are present in the bowel, and calcium is excreted largely by way of the intestinal mucosa.

### ANALYSES IN THE LITERATURE

We have found but two other analyses of appendiceal concretions in the literature.

Roeser [4] examined a concretion weighing 0.56 gm. which had perforated the wall of the appendix and was found free in the peritoneal cavity. It contained 77.2 per cent. of inorganic matter and 11.4 per cent. fatty substance, which were not further examined, quantitatively. Cholesterol, bile pigments and bile acids were missing, the fatty substance was chiefly palmitin, and the inorganic matter consisted almost entirely of magnesium ammonium phosphate, calcium phosphate and calcium carbonate.

Harley [5] analyzed a friable concretion, weighing 1.2 gm., found in an appendix at an operation for appendicitis. Preliminary examination showed organic débris, mostly sclerous vegetable structures, a few granules of silicates, occasional trichocephalus ova, and the absence of bile pigment, cholesterol, bile acids or uric acid. Quantitative analysis of the air dried concretion showed 13.16 per cent. water, 64.61 per cent. ash, and 22.23 per cent. organic matter and material volatilized in ashing. The ash was calculated to contain, in per cent. of the dry matter, magnesium ammonium phosphate, 4.78, calcium phosphate, 63.61, calcium carbonate, 7.54 per cent.; iron and silica, traces. In the organic material was 6.3 per cent. fatty acids. No attempt was made to determine whether any of the fatty acids were combined as calcium soaps. Evidently this concretion was similar in composition to ordinary calcification deposits in necrotic tissues, such as have been described in and about the appendix,[6] and probably represents the calcification of a healed appendiceal abscess, since the stone is said to have been found "au milieu d'adhérences," and is not at all similar to the true appendiceal stones, which Williams found to contain but little calcium.

### AUTHORS' TESTS

Dr. E. R. LeCount has kindly placed at our disposal for analysis a collection of appendiceal concretions found in appendixes removed at operation, at St. Luke's Hospital, Chicago, and collected during the routine examination of these appendixes in the laboratory. The stones were received preserved in a very little weak alcohol, in three

4. Roeser: J. de pharm. et de chim. **4**:251, 1896.
5. Harley: J. de pharm. et de chim. **2**:433, 1910.
6. Rowan and Wells: Surg., Gynec. & Obst., Oct., 1906, p. 503.

separate lots, of from five to ten stones each; and, to secure information as to the average composition of fecal concretions, the stones in each of the three lots were analyzed together. The masses were generally 5 to 10 mm. in diameter, and for the most part dark brown, only two stones (in Group 2) being made up of concentric layers of a white soapy substance, like the concretions analyzed by Williams. When dried to a constant weight at 100 C., the three collections weighed (1) 4.1413 gm., (2) 3.0049 gm., (3) 5.5842 gm.

The material of each lot after pulverizing was extracted by shaking with 150 c.c. of cold water, and the fatty acids of the water-soluble soaps liberated from these water extracts by acid, were determined.

TABLE 1.—Fatty Acids of Water-Soluble Soaps Present in Collection of Appendiceal Concretions

| Groups | 1 | 2 | 3 |
|---|---|---|---|
| | Per cent. | Per cent. | Per cent. |
| Fatty acids (gm) | 0.0090 | 0.0079 | 0.0098 |
| Dry weight (per cent.) | 0.21 | 0.20 | 0.17 |

A small amount of calcium and magnesium were dissolved in water. The percentages of dry weight of these water-soluble constituents are presented in Table 2.

TABLE 2.—Water-Soluble Calcium and Magnesium Present in Appendiceal Concretions

| Groups | 1 | 2 | 3 |
|---|---|---|---|
| | Per cent. | Per cent. | Per cent. |
| Calcium | 0.021 | 0 07 | 0.026 |
| Magnesium | traces | ..... | ..... |

The residue from the water extraction, after drying, was extracted with absolute ether in a Soxhlet extractor. The extracts thus obtained amounted in per cent. of total dry weight to 20.02 per cent. in Group 1; 17.87 per cent. in Group 2; 15.83 per cent. in Group 3.

The ether extracts were then extracted with hot acetone. The acetone soluble portions contained cholesterol, koprosterol, coloring matter and presumably other lipins in small amounts. The cholesterol was recrystallized from 90 per cent. hot alcohol. It gave the Salkowski and Pettenkofer reactions, and was determined quantitatively by the digitonin method. The koprosterol was crystallized from 85-90 per cent. alcohol and showed the slow development of the orange-red color on addition of chloroform and sulphuric acid which differentiates koprosterol from cholesterol (Abderhalden). The values obtained in percentage of total dry weight are presented in Table 3.

The acetone-insoluble portions were treated with cold ether, which removed the color almost completely and probably some lecithin, since it gave Pettenkofer's reaction (sulphuric acid and sugar). The residue from the cold ether was dissolved entirely in hot amyl alcohol, which dissolves calcium soaps [7] as well as sodium, ammonium and potassium soaps. Soaps were salted out of the water emulsions of these extracts and the melting points of their fatty acids determined. Table 4 shows the amounts of soaps present, calculated in percentages of dry weight, and the percentage amounts of calcium found.

Evidently, then, very little of the soap present in this fraction could have been calcium soaps. The soaps were saponified and the free acids extracted with ether. These fatty acids had the following melting points: Group 1, 49 C.; Group 2, 52 C.; Group 3, 57 C., indicating that they are chiefly mixtures of stearic and palmitic acids with some impurities.

TABLE 3.—Cholesterol, Koprosterol and Lipins in Appendiceal Concretions

| Groups | 1 Per cent. | 2 Per cent. | 3 Per cent. |
|---|---|---|---|
| Cholesterol | 1.6 | 1.7 | 0.87 |
| Koprosterol | 9.6 | 14.6 | 9.1 |
| Lipins (by difference) | 0.19 | 0.22 | 0.13 |

TABLE 4.—Soaps Present in Appendiceal Concretions

| Groups | 1 Per cent. | 2 Per cent. | 3 Per cent. |
|---|---|---|---|
| Amyl alcohol soluble soaps | 7.8 | 0.34 | 5.3 |
| Calcium | 0 016 | 0.03 | 0.001 |

The residue from the first ether extraction was extraced with boiling amyl alcohol and the extracts analyzed for calcium and magnesium. The figures presented in Table 5 give the percentages of calcium and magnesium of the total dry weight soluble in amyl alcohol.

The calcium soaps, calculated as calcium stearate from these calcium values, would amount to these percentages of the original dry material: Group 1, 1.1 per cent.; Group 2, 8.9 per cent.; Group 3, 2.56 per cent.

The percentages of original materials extracted with hot amyl alcohol were: Group 1, 38 per cent.; Group 2, 21.9 per cent.; Group 3, 38.8 per cent.

The residue from the first ether extraction was extracted with boiling 1 per cent. nitric acid, and the determinations presented in Table 6 made. Results are given in percentage of original dry concretion.

7. Wells, H. Gideon: J. M. Res. 1906, **14**:359, 1906.

TABLE 5.—Calcium and Magnesium Soluble in Amyl Alcohol

| Groups | 1 Per cent. | 2 Per cent. | 3 Per cent. |
|---|---|---|---|
| Calcium | 0.22 | 1.26 | 0.36 |
| Magnesium | 0.005 | 0.006 | 0.007 |

TABLE 6.—Inorganic Constituents

| Groups | 1 Per cent. | 2 Per cent. | 3 Per cent. |
|---|---|---|---|
| Carbon dioxid | 0.84 | 0.85 | 0.51 |
| Calcium | 6.3 | 13.7 | 5.01 |
| Magnesium | 0.83 | 1.6 | 1.19 |
| Phosphorus | 3.6 | 7.51 | 3.17 |
| Ammonium | 0.4 | 0.35 | 0.38 |
| Ferric iron | 0.08 | 0.2 | 0.11 |

These elements may have been combined as shown in Table 7, in per cent. of original materials.

TABLE 7

| Groups | 1 Per cent. | 2 Per cent. | 3 Per cent. |
|---|---|---|---|
| Calcium phosphate | 13.02 | 27.17 | 7.72 |
| Magnesium ammonium phosphate | 4.73 | 9.18 | 6.82 |
| Calcium carbonate | 1.91 | 2.05 | 1.18 |
| Calcium—excess as sulphate or other salts | 4.6 | 2.4 | 2.7 |

TABLE 8.—Results of Chemical Analysis of Appendix Concretions*

| Groups | 1 Per cent. | 2 Per cent. | 3 Per cent. |
|---|---|---|---|
| Inorganic material | 24. | 41. | 18. |
| Calcium phosphate | 13.02 | 27.17 | 7.72 |
| Calcium carbonate | 1.91 | 2.05 | 1.18 |
| Magnesium ammonium phosphate | 4.73 | 9.18 | 6.82 |
| Calcium (undetermined) | 4.6 | 2.4 | 2.7 |
| Ferric iron | 0.08 | 0.2 | 0.11 |
| Fatty acids liberated from water-soluble soaps | 0.21 | 0.20 | 0.17 |
| Total substances soluble in fat solvents | 58.23 | 39.07 | 54 80 |
| Substances soluble in ether | 20.02 | 17.87 | 15.83 |
| Cholesterol | 1.6 | 1.7 | 0.87 |
| Koprosterol | 9.6 | 14.6 | 9.1 |
| Soaps soluble in both ether and amyl alcohol | 7.8 | 0.34 | 5.3 |
| Other lipins | 0 19 | 0.22 | 0.13 |
| Substances soluble in amyl alcohol and insoluble in ether, probably soaps | 38. | 21.9 | 38.8 |
| Calcium soaps calculated as calcium stearate | 1.1 | 8.9 | 2.56 |
| Organic residue (not analyzed) | 17. | 20. | 26. |

*Figures represent percentages of the original dried material.

The percentage of total calcium found in all forms was: Group 1, 6.55 per cent.; Group 2, 15.06 per cent.; Group 3, 5.37 per cent.

## SUMMARY

The composition of three collections of concretions found in human appendixes was found to vary somewhat, but in general there was a similarity in the makeup of each lot of concretions (Table 8). They contain about half their weight soluble in fat solvents, this material being chiefly soaps, but with considerable koprosterol and a little cholesterol. Of the soaps but a very small proportion seems to have been calcium soaps. About one fourth of the total weight was composed of inorganic material, chiefly calcium phosphate. About one fifth of the material was organic residue, mostly vegetable fiber, indicating that some part of the appendiceal concretions, at least, comes from the cecum. Probably the rest of the concretions is deposited from the walls of the appendix, since the bowel secretions are known to contain much fatty material and calcium.

We wish to express our indebtedness to Dr. E. R. LeCount for the opportunity to make this study, through his generous gift of the necessary materials.